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ABSTRACT

The theme of this conference was intended to reflect the changes in the economic and educational environment and the changing perceptions of science educators in the United States and in the United Kingdom since the first such seminar which occurred in 1982. The document includes the text of the keynote address by F. James Rutherford entitled "Second Thoughts on a Theme: Science Education in a High Technology Society." Other sections of the proceedings contain papers on: (1) cost effective science education; (2) the appropriate use of high technology in the classroom; (3) meeting the needs of diverse learners; (4) research in science education; (5) providing professional support for teachers; and (6) strengthening the voice of professional associations in science education. A summary of the conference, and comments by Valerie B. Payne and Cindy Hrebar to the annual meeting of the National Association of Science Teachers are included. The appendixes include a description of the British and American educational systems. (TW)

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SCIENCE EDUCATION IN A HIGH TECHNOLOGY SOCIETY:

PROCEEDINGS OF A CONFERENCE

Sponsored by Boston University
for
The National Science Teachers Association of the United States
and
The Association for Science Education of the United Kingdom

March 31-April 2, 1984
Boston, Massachusetts

Edited By
Albert G. Medvitz

January,1985

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PREFACE

This meeting follows a similar meeting held in 1982 at Chelsea College, London. The motivation for the first meeting was a need to share ideas, and knowledge about successes and problems. Following the success of the first meeting, its organizers, Frank Sullivan and P.J. Black, set in motion the machinery for a second U.S./ U.K. seminar. At the 1983 Dallas meeting of the National Science Teachers Association representatives of the NSTA and the Association for Science Education concurred on the desirability of the meeting. Since Boston was to be the sight of the 1984 NSTA annual conference, it was chosen to be the venue for the smaller bi-national meetingas well. Boston University was to sponsor the meeting on behalf of the NSTA and the ASE to take place immediately before the NSTA annual conference so that the participants could convey the outcomes of the conference to those gathered there.

The theme of the second meeting, "Science Education In A High Technology Society", reflects the changes in the economic and educational environment and the changing perceptions of science educators since the 1982 meeting. "High Tech" industries continued to grow and there was (and is) increased marketing pressure to use computers as a tool of instruction. In the United States a number of reports had been published decrying the neglected state of science education in the United States as a threat to national security and economic strength. New funds were becoming available from Federal sources and new interest was evident at state and local levels.

The theme of the meeting and the reflection of that theme in the topical choice of the presentations indicates the perception of the need for a careful analysis of the past before proceeding headlong into the future. Despite the criticism at the national level, the organizers recognized that much good work was being pursued by creative individuals working with constrained resources in schools and local authorities on both sides of the Atlantic. The strategy of the meeting was to bring together representatives of this group of practitioners with researchers, teacher trainers, and leaders in the teachers associations to address longstanding unsolved problems and some new ones. Among these were the persistent problem of providing adequate education in the sciences for previously difficult to reach groups particularly young women and ethnic and linguistic minorities; the problem of providing adequate professional support to teachers; the problem of maximizing effects in times of constrained resources. The problem of the appropriate use of high technology in the classroom and the problem of strengthening the leadership role of professional associations in the context of high-technology societies in which old problems persist while new ones arise.

The organizers used a deliberate strategy to select people who previously had not had the opportunity to participate in an international meeting as well as those who had. In the United States a heavy reliance was placed on the NSTA Search for Excellence Program as a pool from which to select seminar participants. Thus, new ties between our younger science education leaders in the U.K.and U.S. could be established.

By all accounts of those who participated in the meeting, it was a great success both intra- and internationally. The cross cultural and cross national interactions forced a continuing examination of basic assumptions as well as the details of practice among the participants. Ultimately, however, the value of the meeting must be measured in its long term outcomes. It must be measured in the degree to which lessons learned are transmitted from the few participants to the wider professional community. These proceedings are one means of doing so. Other means are the presentations and writings of the participants which began within a few months after the meeting itself.

This meeting had fewer paper presentations than the earlier meeting. In the preparation of the proceedings there was little concern for paring length and every effort was made to maintain the flavor of the diversity of discussion in the small groups and the plenary sessions.

The 1984 meeting could not have been carried out without the support of many people and organizations. The National Science Foundation provided basic support for the conference. Both the School of Education and the College of Basic Studies and Boston University provided generous use of meeting rooms and organizational support. Several corporations provided important additional financial support. Particular thanks are due to:

The Digital Equipment Corporation
The Gillette Corporation
New England Telephone

Finally, much of the success of the meeting is due to the advice and efforts on the U.K. side by Brian Atwood of the ASE. Special thanks are due Michael Berenbaum Associates for the preparation of the manuscript of these proceedings while under great time pressure.

Albert G. Medvitz
Gerald L. Abegg
Frank L. Sullivan
Warren Tomkiewicz

INTRODUCTION

The Conference Keynote Address:

Second Thoughts On The Theme: Science Education in a High Technology Society

F. James Rutherford

Dr. F. James Rutherford
American Association for the Advancement of Science
Washington, D.C.

SECOND THOUGHTS ON THE THEME
SCIENCE EDUCATION IN A HIGH TECHNOLOGY SOCIETY

When I was invited to make a presentation at this meeting, my first thoughts had to do with presenting a cogent argument for more and better science education in the United States and the United Kingdom. I discarded this idea because further argument to make that point is not needed.

As the title of the talk implies, I want to share with you my second thoughts about the current arguments for reform in science education. These thoughts are about the need for some caution in making our claims for reform and in our assumptions about the matters at hand.

The theme of the conference is so encompassing that I won't try to deal with the whole. Rather, I will deal with the parts of the theme in a provocative rather than systematic way and, with luck, the conference will be able to put the parts together again.

My remarks will focus on three broad topics. These are:

1. the nature of a HIGH TECHNOLOGY SOCIETY or, in other words, the cultural context in which this conference has elected to

examine science education.

2. some aspects of EDUCATION IN GENERAL that bear on what can be expected in the way of change; that is, the educational context of the issues at hand.
3. the relationship of the cultural context and the educational context to science education.

To avoid any misunderstanding let me make it clear that science and technology are at the center of human culture. They color our entire existence. They provide our greatest hope for progress and the greatest threat to our continued existence.

HIGH TECHNOLOGY SOCIETY AS THE CULTURAL CONTEXT

If we roughly define technology as the way that human beings do things using tools, then the question arises, How is a "high technology" society different, if at all, from:

an industrial society?
a learning society?
an information society?
a consumer society?
a democratic society?

The term "high technology society" implies that such a society is independent of political philosophies, but not "the economy." Thus, defining science education for a "high tech" country does not address other dimensions and contexts that may be of equal consequence. Addressing the issue of science education for a high technology society may be necessary in order to address the problems of today, but it is certainly not sufficient. Clarification might come if we consider the difference between today's technologies and those of earlier times.

One of the differences between science and technology today as compared to those of the past is the increasing interdependence between science and technology. Historically, science and technology have not always been so interdependent. In many cases in the past science and technology developed entirely independent of one another. This is less the case today.

Another difference is that today the rate of development in science and technology is greater than before. The rate of change itself is increasing. The rate of growth in knowledge and its application is so fast that technologies leapfrog international boundaries. Internationalization is being spurred on by the new technologies. In many ways this internationalization is beyond the control of existing political systems at national and international levels.

There are also differences between today and yesterday in the character of the new technologies themselves. One of these is the intimacy of the effects of the new technologies as compared to the old. Many of the new technologies have a direct and immediate effect on the character of actions in our daily lives. "The pill," pacemakers, "personal" computers, new versions of the telephone, radio, television, LP and digital disc recording techniques, psychological testing, mass polling techniques and associated social and economic projections, all affect us in direct ways. Many people in the society not only produce, but also consume in direct ways the fruits of new technologies.

Associated with the intimacy of the effects of the new technologies is their subtlety. We are often not aware of the profound effects inherent in the action of the new technologies. Where older technologies required high energy consumption and were highly visible, many of today's new technologies (and new versions of older technologies) are low in energy consumption and act with "transparency" to change the structures of our individual lives and of our societies.

THE EDUCATIONAL CONTEXT

Primary among the realizations about education in any discussion of the task of reform is that institutionally education is adaptive rather than subversive. There is an inherent conservative bias in the practice of education. But the world of science and technology to which education must adapt is in itself revolutionary. The world of science and technology is dynamic, with accelerative rates of change, rather than static. There is an ever-increasing burden for educational practice and institutions to change more rapidly and they are ill-equipped to do so.

Another realization is that education is now in competition with other societal demands that did not exist before. Health, housing, old age pensions, environmental preservation, and transportation are all placing claims on the public purse. Some, but only some, of these new claims result from dramatically changed economic conditions. There are other factors at work.

Much of the competition for educational funds arises from fundamental demographic changes in our society, especially the aging of the population. An aging population brings with it differing social mores and work patterns. For example, continuing education for middle-aged and older populations is an increasing new demand. Also, working women are demanding preschool and day-care centers, which they did not demand before.

In short, schools are pushed and pulled by forces outside of their control. The changing patterns just mentioned produce tensions between egalitarian and elitist goals: between competition to get ahead and cooperation and sharing. They produce tensions between the function of schools as custodial institutions and as places of "learning."

In this regard, the recent movement to bring about educational reform should focus on "schooling," rather than on "education." Education is too diffuse a concept. Focusing on schooling allows us to concentrate on the necessity of connecting schooling to out-of school learning opportunities and demands. One of these connections is that schooling should be preparation for lifelong learning in a scientific and technical world.

But schooling is not _just_ preparation for something else later in life. Schooling is more than instrumental; it is also an _experience_ to be valued in its own right. This view, which has consequences for science education, is different from images that portray schooling as something else. The most common images portray schooling as filling a container (or transferring knowledge), as exercising brain muscles (or developing intellectual skills), or as going to secular chapel (instilling values).

Schooling as an experience is different. It results in a rich set of understandings and insights, of feelings about one's self and the world, and of "inclinations" and "savvy." When a child begins school it provides for the development of a sense of "neighborhood." In middle school years it provides for a sense of "self." In the ending years of school it provides for a sense of "context and discipline." These outcomes are fundamentally different from knowledge, skills, and values.

NEEDED CHANGES

Dramatic changes are required in the current educational or school context. One of these changes is the revitalization of teaching. Teachers require the chance to succeed: to obtain approval and acceptance. They need stimulating working circumstances with compensation reasonably in line with other public service occupations.

In practical terms these needs would be translated into year-round employment. The changes would place greater emphasis on administrative, material, and technical support of teachers, and on special efforts to develop team identities in schools. New modes of sanction would need to be developed along with new patterns of recruitment, education, training, and placement of teachers.

What is called for is no less than a modernization of schooling both technologically and organizationally in the use of time, facilities, resources, teachers, and students.

STRATEGY AND THE REFORM DILEMMA

To achieve effective reform it is essential to develop a strategy to address the "reform dilemma" posed by schooling. The reform dilemma, simply stated, is that radical change in the schools is usually rejected, while evolutionary change falls behind need. The dilemma is posed whether or not reform attempts are "top down" or "bottom up" in strategy. The dilemma arises in part because of the connectedness of the schooling enterprise, *viz*., the relationship of schooling to the teacher, the curriculum, materials, and so forth. It arises in part also because of the capitalization and aggregation of the enterprise in large institutions and organizations. Reform can be very effective at the level of the individual teacher or individual school, but is extremely difficult at district and state levels, let alone national and international levels. Time and effort are required to recognize the dilemma and develop an effective strategy to cope with and overcome it.

EDUCATION AND SCIENCE

If human civilization exists for a lifespan or longer, it will be because we come to terms with ourselves as generators of knowledge and users of technology. Thus, all of school must have as a major purpose education in science and technology, not just "science education." In general the core of reform in schooling needs to be recognized as curriculum development. It is essential to develop a school experience that takes its character from the world as it is and as it is becoming. And that is a world shaped, for better and worse, by science and technology.

Curriculum development and implementation is the overriding need. It must cut across all aspects and domains of schooling. It needs to be the focus of teacher training, of restructuring the schooling process, of materials development, and of research.

Work to meet this overriding need ought to be based on an understanding of what outcomes--experience, knowledge, insights, skills, etc.--we want all graduates to have. In light of this assertion, the corollary is that the curricular contents of all courses need to be reexamined in terms of these understandings.

Clearly, there are no easy formulae. Integrated science, STS, computer literacy, are all attempts at finding the answers to the questions of reforms. But each, in and of itself, is insufficient. A broader, more coherent, view of science and technology in today's society, along with a broader and more coherent view of schooling as a social and institutional process, is essential to make future reform efforts meaningful, let alone successful.

It is with this search for a clearer and more coherent view of science, technology, and society and science education that I leave the conference to consider its tasks.

PART I

COST EFFECTIVE SCIENCE EDUCATION

Papers by:

Sid Sitkoff
Michael J. Williams

Discussion

Dr. Sid Sitkoff
Los Angeles Unified School District
Office of Instruction
Science Office

STONES AND BONES: A LABORATORY APPROACH TO THE STUDY OF PHYSICAL ANTHROPOLOGY

An Overview

"Stones and Bones" is a new and innovative secondary school science program that enriches and extends the present study of Biology, Modern (General) Science and Anthropology courses in grades seven through twelve. The program represents a joint cooperative effort with the Los Angeles Unified School District, the L.S.B. Leakey Foundation and the Los Angeles County Museum of Natural History. "Stones and Bones" is validated by the Joint Diffusion Review Panel and grant recipient through the National Diffusion Network.

The primary objective of "Stones and Bones," A Laboratory Approach to Physical Anthropology, is to enrich and extend the present study of Biology, General Science, and Physical Anthropology at the secondary level by: (a) Providing and developing learning materials that involve students in direct laboratory experiences as well as teacher demonstrations and presentations. (b) Having students use science skills or processes including questioning, identifying problems, observing, hypothesizing, experimenting, gathering data, analyzing, and

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summarizing in their laboratory activities. (c) Guiding students into learning experiences that lead to concept development. (d) Emphasizing the interdisciplinary nature of Physical Anthropology with science areas such as Biology, Chemistry, and Geology. (e) Reinforcing basic skills in mathematics, social studies, and language arts through laboratory explorations.

Instructional components of the "Stones and Bones" program offer three separate approaches to meet the needs of different ability level students. They are: (1) General Science Unit: Specially designed to highly motivate underachieving and noncollege oriented students through a series of twenty-one laboratory investigations to pursue higher academic fields. (2) Biology Unit: Designed as a four to six week overview of Anthropology with hands-on,in-depth experiences to enrich and extend their current Biology textbook. (3)Semester Course: Provides students with the opportunity to study the story of humankind through laboratory activities.

The program affords students both opportunities and benefits that are not usually available in regular classroom programming; contributes substantially to improve student performance in content areas as measured by both reliable and valid instruments; is positively viewed by students, community, and teachers; is perceived by students as contributing to their knowledge base in other required content areas; has resulted in substantial student performance among inner city students regardless of sex and ethnicity; is comprehensible to all levels of students (high, average, low achievers); and has encouraged female students to pursue the field of science.

The program's printed and multimedia instructional materials are designed for varying ability levels from the nonacademic to academic students. All instructional materials, including fossil replica casts, are scientifically accurate.

Teacher training workshops are conducted to insure effective implementation. Ongoing technical assistance is available by project staff to adopting schools.

Objectives

The performance objectives of the program include:

1. Demonstrating that Physical Anthropology can be taught to high, average, and low achieving students, and that gains are reflected in project groups regardless of sex or ethnicity.

2. Protecting the integrity of each student's personal philosophy about the development of humankind.

3. Promoting new learning motivation in students.

Regarding the laboratory emphasis, students investigate: (1) fossil evidence as it applies to humankind; (2) fossil evidence related to geological strata and periods; (3) structural and functional similarities and differences among fossils; and (4) the process of adaption and behavior.

Rationale:

The rationale for "Stones and Bones" is based upon the development of a new instructional program in Physical Anthropology that relates to present day curricula and provides new learning motivation for students through a classroom and laboratory-type approach. The program impacts on present secondary-level courses in Biology, Modern (General) Science, and Anthropology. The interdisciplinary nature of the subject area also involves such subjects as Physiology, Chemistry, Geology, Mathematics, and the Social Sciences.

Extensive surveys of learner needs were conducted prior to the program's initiation: (1) surveys of science department chairpersons representing forty-nine senior high schools and four hundred Biology teachers indicated that Physical Anthropology is not taught as a part of the secondary curriculum although it is included in most secondary Biology textbooks; (2) a Los Angeles city schools districtwide survey indicated that Physical Anthropology, as a one semester course, was taught to one class of twenty-five students in a high school population of 135,000; (3) there is a lack of an interdisciplinary approach within the sciences and in relation to other subject areas; (4) on a national scale, a LANCER (ERIC) search, conducted through the facilities of the Los Angeles County Education Offices, indicated that there is no evidence of Physical Anthropology classes being taught in either a didactic or laboratory setting; (5) there is no evidence of test items on Physical Anthropology in any of the California state or national education testing programs; and (6) existing science programs are seldom designed for low-achieving students.

Content and Strategy:

The program offers three separate instructional approaches designed for varying ability levels from the nonacademic to academic (university-oriented) students.

BIOLOGY UNIT

The Biology Unit is a four to six week overview of Physical Anthropology. This unit provides students with hands-on, in-depth experiences as an enriched supplement to the presentation of Anthropology by their Biology textbook. A series of eleven student laboratory explorations focus on topics including primate behavior and distribution, interpreting the archaeological record, primate locomotion and morphology, and early hominids. Fossil specimens are cast and made available especially for the program. This approach reinforces and extends many basic concepts taught in the study of Biology. Unique features of the Biology unit, in addition to other media materials, are a syllabus and illustrated study dictionary as well as visual aids illustrating the progress of the class in a bulletin board display.

MODERN (GENERAL) SCIENCE UNIT

The Modern (General) Science Unit is specially designed to highly motivate noncollege oriented students. Each of the twenty-one laboratory explorations offers the general science student opportunities to investigate topics including the geologic time table, measuring radioactivity, locating points on a map, behavior of primates, and fossil hominids. Each of the explorations has a glossary, vocabulary drill, or word puzzle. The student reading series, consisting of booklets on special topics in Physical Anthropology, is illustrated and written in a narrative style with simplified format and lowered readability. During the four to six week unit, students simulate excavation of specimens through the use of tools provided in the fossil dig classroom kit.

SEMESTER COURSE

The Semester Course in Physical Anthropology provides students the opportunity to study in-depth the story of humankind. Laboratory investigations pursue such topics as: phylogeny through time, continental drift, locomotion and behavior of primates, primate classification and morphology, Australopithecus, Neanderthal, Homo erectus and Cro-Magnon. Many supplementary instructional materials for students and teachers are available, including study prints, charts, a filmstrip, and fossil photograph set. This in-depth approach to the study of humankind provides an enriched academic experience in science and may be related to existing classes in Cultural Anthropology.

Instructional methodology directly involves students in Science, Anthropology, and related subjects using processes such as: questioning, observing, hypothesizing, investigating, reading, discussing, listening, recording information, summarizing, and conceptualizing. Teachers encourage student learning in a problem-solving oriented classroom. All three instructional pathways can be utilized with an entire class, learning centers, or other individualized strategies. The instructional materials have been designed for use by students of various ability levels. The availability of multimedia materials further provides for individualization of instruction. It should be noted that all instructional materials have been validated by the L.S.B. Leakey Foundation, Los Angeles County Museum of Natural History, and Dr. Clark Howell, Chairman, Anthropology Department, University of California at Berkley, as well as other internationally recognized anthropologists.

Implementation:

Implementation of the program is readily accomplished with senior high school science staffs by:

1. Using project developed instructional materials, which are self-directive for the student and require minimal teacher supervision. Certain basic supplies (such as paper, pencils, and rulers) are already located at the school.

2. Utilizing existing classroom space.

3. Implementing the program with the Anthropology unit for Biology and/or the Anthropology unit for Modern (General) Science during the first phase (or year) and introducing the full semester Anthropology course during the second year.

4. Having teachers participate in a one-day training session.

5. Using evaluative instruments, developed by the project, for assessing student achievement.

The program's printed and multimedia materials as well as replicas of fossil specimens may be installed in parts or phases in various ways.

PLAN A

The four to six week Anthropology unit for Biology and the four to six week Anthropology for Modern Science may be implemented during the first phase (or year).

The full semester Anthropology course may be implemented during the second phase (or year).

PLAN B

The four to six week Anthropology unit for Biology is implemented during the first half of the school year.

The full semester Anthropology course may be implemented during the second academic year.

PLAN C

All instructional tracks are implemented during the first year.

Concerning All of the Above Plans:

Staff development may be in phases, appropriate to the degree of implementation, and may initially involve the training of instructional leaders who would in turn train teachers and others in subsequent phases.

Additional nonconsumable fossil casts for individualized student use may be purchased at later periods.

The Anthropology program may be readily duplicated in a new location. Factors supporting the project's replicability include:

1. Existing facilities and housing in a district are suitable for this program. There are no special laboratory requirements.

2. The majority of instructional products provided by the project are of a nonconsumable nature.

3. Existing science staff with minimal training (one day) can effectively teach the program.

4. Regarding the printed laboratory material for students, a given school or district may wish to order sufficient project developed materials for all students or order only one printed copy and duplicate that material to meet their school needs. We have found that the secondary school print shop, or a good duplicating machine, can be an important resource for replicating

material.

5. Instructional strategies include laboratory investigations, discussions, demonstrations, and reference reading. These strategies are incorporated into the student and teacher material. The student material is self-directive. However, the teacher plays a significant role in guiding student learning.

Implementation Costs:

Materials:

The "Stones and Bones" program includes basically nonconsumable types of instructional materials. The fossil casts are extremely durable. Printed student copy may be duplicated by the teacher for classroom use. Separate data forms have been developed, allowing students to use the individualized investigations for laboratory activities, and schools may also choose to use the fossil study print set in lieu of fossil casts should their budgets be too limited for cast purchase. It should be noted that the cost of individual casts at $75 each is extremely inexpensive for the quality of casts produced. Former producers of similar casts have charged approximately $400 per cast.

Training:

The program can be effectively implemented with science teachers by reading the teacher's guide developed for each of the three instructional pathways. However, a one day workshop is suggested for effective implementation. The major focus of the workshop is to acquaint teachers with the program, its materials, and strategies and subsequently have the trained staff conduct their own training.

Cost:

For a group of thirty students, the estimated cost would be as follows. (Please note that these costs may be reduced considerably should more than one pathway be implemented since several of the same casts are used in all pathways. These materials may also be shared by classes, thus reducing costs.)

BIOLOGY PATHWAY -- $17.70 per student, first year. The cost per student is significantly lower if materials are shared by more than one class. There is no additional cost for materials after the first year.

MODERN SCIENCE PATHWAY -- $14.50 per student, first year. The cost per student is significantly lower if materials are shared by more than one class. There is no additional cost for materials after the first year.

SEMESTER COURSE PATHWAY -- $40.02 per student, first year. The cost per student is significantly lower if materials are shared by more than one class. There is no additional cost for materials after the first year.

EVIDENCE OF EFFECTIVENESS:

Claims of Effectiveness -- The Curriculum in Physical Anthropology using an interdisciplinary laboratory approach was designed to:

1. Demonstrate that Physical Anthropology can be taught to high, average, and low achieving students, and that gains are reflected in project groups regardless of sex or ethnicity,

2. Protect the integrity of each student's personal philosophy about the development of humankind, and

3. Promote new learning motivation in students.

Evaluation Design -- The product evaluation plan utilized a pre-test and post-test comparison group design. Both target comparison groups were tested at comparable intervals using project developed criterion reference tests. Mean raw scores, mean percent correct answers, and standard deviations were used to analyze the comparability of scores before the introduction of project materials and the difference in test performance subsequent to project instruction.

Process evaluation consisted of project developed surveys which measured perceived effectiveness and utility of project developed materials and attitudes about the overall project curriculum. These surveys were administered to both teachers and students. In the early stages of project development, data from these surveys were important to project refinement.

Selection of Participants -- In essence, teachers were self-selected; i.e., they volunteered to use the materials in their normally scheduled classes after hearing a description of the project through administrative channels. Project students in the Bio-Anthro and Modern Science strands, therefore, were included solely on the basis of their teachers' assignments. Semester course students either elected the course or were advised to enroll by their counselors.

The project operated in eighteen public schools and two private schools. One school taught all three strands, while only one strand was taught in the remaining nineteen schools.

Description of Sample -- Twenty-eight teachers taught the project. Thirteen of them were undergraduate Biology majors;

five majored in Zoology, one in General Science, one in Geophysics, two in Psychology, and two in Anthropology. Only five teachers held graduate degrees, four in Biology and one in Anthropology. Except for the two undergraduate and one graduate Anthropology majors, only thirteen teachers had any formal classwork in Physical Anthropology (ranging from 1 to 12 credits.)

Fifteen of the teachers taught science at the secondary level for ten or more years, six for five to eight years, and three for less than five years. This information suggests that the teachers involved in the project were not extraordinarily credentialed to teach Physical Anthropology.

These points emphasize that the success of the program is not contingent upon its implementation by teachers with highly specific backgrounds in Physical Anthropology.

The Bio-Anthro strand was taught in twenty-three Biology classes comprised, by teacher description, of average and above-average students. The semester course, taught in seven classes, involved above average science majors or students satisfying a social studies requirement. The Modern Science strand was taught in six classes where students were enrolled to meet the minimum science requirement for high school graduation.

Instrumentation -- Product evaluation included a criterion referenced instrument for each strand and a concept test (criterion referenced) administered to all three strands. These tests were developed by the project coordinators, the project anthropologist, and professional experts engaged by the project for this purpose. The reliability coefficient (coefficient of internal consistency) adjusted by the Spearman-Brown prophesy formula, for the Bio-Anthro test = .93; for the semester test = .82; for the Modern Science test = .84; and for the concept test = .75.

The Kuder-Richardson-Hoyt coefficient for the concept test was .72, thereby suggesting that the test items are homogeneous and valid. Validity for the three strand tests was established through item analysis. Eighty-two percent of the Bio-Anthro test items discriminate successfully between those scoring high and those scoring low on the post-test. In the semester test, fifty-three of the items discriminated successfully, with most students getting twenty-one percent of the remaining items correct and three percent incorrect. Similarly, seventy-four percent of the items on the Modern Science test discriminated successfully, with most students answering six percent of the remaining items correctly.

All four tests are deemed sufficiently reliable and valid as measures of project effectiveness. The Bio-Anthro test was revised twice (at the end of the first and second project years) and the semester test once (at the end of the second project year). The Modern Science test was instituted during the final semester of the third project year.

Credibility of Evaluation Procedures -- An evaluator, hired from outside the district, developed the evaluation design in consultation with project staff. The evaluator also worked closely with the project coordinator during program implementation, overseeing the inclusion of comparison groups and data collection procedures and providing timely feedback which facilitated the appropriate revisions in instrumentation, instructional materials, and project procedures.

All project classes were tested. Bio-Anthro Unit and Modern Science classes were pre-tested and post-tested at the beginning and end of six week intervals. The semester course students were tested at the beginning and end of the semester. In the Bio-Anthro unit, test scores were reported for eight classes, chosen by stratified random sampling so as to include two classes each from the four ethnic groups most representative of the diversity within the district. Scores for all classes in the other strands are reported.

Comparison groups for each of the strands were selected from classes of like content. For the Bio-Anthro strand, classes were randomly selected from schools other than those in which the project was operating. Two classes in each of four schools reflecting specified ethnic groups were included. For the semester course and Modern Science strand, logistical constraints required that comparison classes be selected from the same schools in which the project was operating. The comparison group teachers, however, were not privy to project materials, thereby reducing the effects of potential contamination. For the semester course, one comparison group was chosen from Cultural Anthropology classes in each of seven schools. One class in Modern Science from six schools was chosen in similar fashion to constitute the comparison group for this strand.

The comparability of pre-test performance scores between project and comparison groups is reflected in Table 1.

Table 1

Pre-Test Scores for Project and Comparison Groups
for Bio-Anthro Unit, Semester Course and Modern Science Unit
1979-80 Project Year

	Bio-Anthro		Semester		Modern Science	
	Proj.	Comp.	Proj.	Comp.	Proj.	Comp.
# of Test Items	48	48	64	64	50	50
Mean Raw Scores	13	13	21	21	16	16
Mean % Correct Answers	27%	27%	33%	33%	32%	32%
Standard Deviations	4.48	4.62	6.24	6.06	5.15	5.31
# of Students	177	119	134	84	129	130

Evidence to Support Claim #1 -- A comparison of pre-test and post-test scores for project and comparison groups in all three strands supports the claim that project materials and instructional sequence enrich and expand the established curriculum in identified science classes at the secondary level.

Table 2

Pre- and Post-Test Scores for Project and Comparison Groups
Project Year 1979-80

	Bio-Anthro				Semester				Modern Science			
	Proj.		Comp.		Proj.		Comp.		Proj.		Comp.	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
# of Test Items	48	48	48	48	64	64	64	64	50	50	50	50
Mean Raw Scores	13	29	13	12	21	44	21	23	16	25	16	17
Mean % Correct Answers	27%	60%	27%	25%	33%	69%	33%	36%	32%	50%	32%	34%
Standard Deviation	4.48	8.42	4.62	5.34	6.24	8.53	6.06	5.11	5.15	6.42	5.31	5.43
# of Students	177	177	119	199	136	138	84	84	129	129	130	130

Project group scores, measuring knowledge of Physical Anthropology, increased by 16 points in the Bio-Anthro unit, by 23 points in the semester course, and by 9 points in the Modern Science unit, representing 123 percent, 110 percent, and 56 percent improvement rate respectively. By contrast, comparison group scores decreased by one point in the Bio-Anthro unit, evidenced no change in the semester course, and increased by 1 point in the Modern Science unit.

A similar trend can be noted for the Bio-Anthro unit during project years 1977-78 and 1978-79 and for the Semester Course during Spring, 1979 and Fall, 1979.

Table 2A

Pre- and Post-Test Scores for Project and Comparison Groups - Bio-Anthro Unit
Project Years 1977-78 and 1978-79

	1977-78				1978-79			
	Proj.		Comp.		Proj.		Comp.	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
# of Test Items	75	75	75	75	50	50	50	50
Mean Raw Scores	23	41	23	25	14	29	12	12
Mean % Correct Answers	31%	55%	31%	33%	28%	58%	24%	24%
Standard Deviation	6.50	10.39	5.95	7.50	4.49	7.22	3.30	3.85
# of Students	226	226	213	213	213	213	179	179

Table 2B

Pre- and Post-Test Scores for Project and Comparison Groups - Semester Course Spring, 1979 and Fall, 1979

	Spring, 1979				Fall, 1979			
	Proj.		Comp.		Proj.		Comp.	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
# of Test Items	82	82	82	82	64	64	64	64
Mean Raw Scores	25	49	26	28	22	40	21	22
Mean % Correct	30%	60%	31%	34%	34%	63%	33%	31%
Standard Deviation	8.03	6.80	8.07	8.58	6.97	11.26	7.02	7.23
# of Students	16	16	26	26	44	44	61	61

Differentiated Effects -- Noteworthy differences in scores by sex and ethnicity were observed. Table 3 depicts these trends for the Bio-Anthro unit in the 1978-79 year.

Table 3

Pre and Post Scores of Bio-Anthro Unit Students
by Sex and by Ethnicity
1978-79

Ethnicity	Male						Female					
	Pre-Test			Post Test			Pre-Test			Post-Test		
	*MRS	%50 Items	S.D.	MRS	%50 Items	S.D.	MRS	%50 Items	S.D.	MRS	%50 Items	S.D.
Black	13	26%	4.52	29	58%	5.13	12	24%	3.84	29	58%	7.99
Integ.	15	30%	3.44	30	60%	8.49	10	20%	2.18	30	60%	6.98
Hisp.	14	28%	4.39	26	52%	6.61	14	28%	3.70	24	48%	5.32
White	18	36%	5.10	33	66%	6.46	16	32%	4.38	29	58%	5.49

*MRS = Mean Raw Score

The Black group improvement rate was the highest (95%) followed by the Integrated group (91%), the Hispanic group (73%) and the White group (55%). There was comparable post-test performance between the Black, Integrated, and White groups, and all of their performances were substantially higher than that of the Hispanic group.

Females in the Integrated group improved by 200 percent, in the Black group by 125 percent, the Hispanic group by 71 percent, and the White group by 81 percent. Among the male group, the Integrated group improved by 100 percent, the Blacks by 123 percent, the Hispanics by 85 percent, and the White by 83 percent. This means that within the Black and White groups, the male and female improvement was nearly comparable while the males in the Hispanic group made greater overall gains than the females in that group, and the females in the Integrated group made even greater strides than the males in their ethnic group. Generally, though male scores tended to be slightly higher than female scores, females tended to demonstrate greater growth than did males.

Project students in all three strands were given the same test immediately following the completion of project instruction. The results are displayed in Table 4.

Table 4

Scores of Basic Concepts Text 1979-80

Students	Mean Raw Score	Percentage of 28 Items	Standard Deviation
Bio-Anthro (n=314)	18	64%	4.95
Semester (n=76)	22	85%	3.93
Modern Science (n=121)	10	36%	5.06

The scores of the typically low achieving Modern Science students underline the point that anthropological facts can be taught at all student ability levels.

Evidence to Support Claim #2 -- It was the project's intent that students view the study of Physical Anthropology as one of many ways of understanding the development of humankind, to be or not to be accepted depending upon their personal values and dispositions. Using Likert type scales, students were asked to respond to the following three statements:

1. "I think that the study of Physical Anthropology is the only approach to understanding the evolution of humankind."

2. "I think that there are approaches other than the study of Physical Anthropology to understanding the evolution of humankind."

3. "I think that physical anthropologists feel that the study of fossils has provided them with complete knowledge about the evolution of humankind."

The responses of 444 students exposed to all three strands are found in Table 5.

Table 5

Student Responses to Statements
About Approaches to Studying the Development of Humankind

Statement No.	Agree	Disagree	Neutral
1.	49%	25%	25%
2.	58%	13%	29%
3.	46%	31%	23%

These data suggest that students are not imposed upon ideologically by the nature of project curriculum content and that they maintain their freedom to adopt a personally comfortable view of the changes in humankind over time. Also, the project has been in operation over four years. During this time, no complaints about curriculum content or approach from school administrators, religious organizations, or students have been received.

Evidence to Support Claim #3 -- A reflection of learning motivation is gleaned from absenteeism observed (1) during project instruction and (2) after project instruction.

Table 6

Absence Rate for Project and Comparison Groups
Bio-Anthro Unit
1978-79

	During Project Instruction (38 days)	After Project Instruction (31 days)
Project Group 8 classes	8%	12%
Comparison Group 8 classes	19%	19%

The difference in the absentee rate between the project and comparison groups during the project instructional period is marked. It is more pertinent that the comparison group absentee rate remain the same for both assessment periods while the absences rose for the project group after project instruction was completed. This is attributed to the impelling nature of the project curriculum and materials.

As further support of the claim of increased learning motivation, students report that the knowledge gained in the project is transferable to other curriculum areas. Students (n=444) report that the project curriculum assisted them in other subject areas in the following proportions: History, 72%; other Sciences, 66%; Social Studies, 55%; Mathematics, 48%; English, 35%; and Foreign Language, 17%.

Finally, students in the Bio-Anthro unit indicated that, if available, they would enroll in a Semester Course in Physical Anthropology. For 1977-79, 33 percent of the students felt this way; for 1978-79, 32 percent, and for 1979-80, 34 percent felt this way.

Evidence that Effects are Attributable to the Intervention -- The project was continued for three consecutive years with essentially the same project and teaching staff and the same evaluation design but with different students. Figures 1, 2, and 3 show the score gains for project and comparison groups in the Bio-Anthro unit and semester course over three instructional periods and the Modern Science course for one instructional periods and the Modern Science course for one instructional period. Since 1980 marked the end of the project's developmental phase, there was no opportunity to further test Modern Science groups.

Project Groups ▲————▲
Comparison Groups ●————●

Figure 1

Bio-Anthro Unit Score Gains, 1978-80

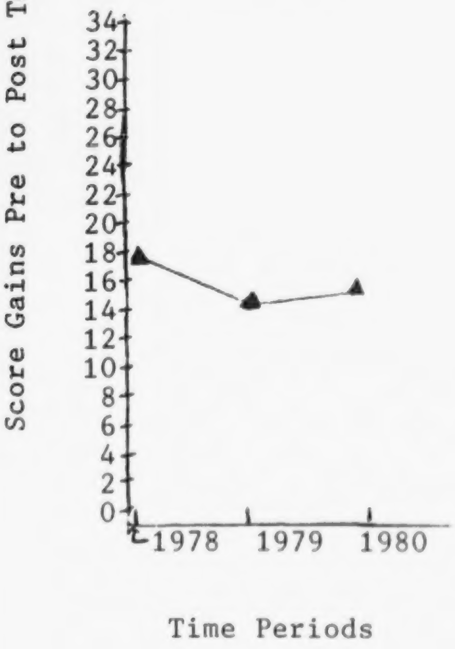


Figure 2

Semester Course Score Gaines, 1979-80

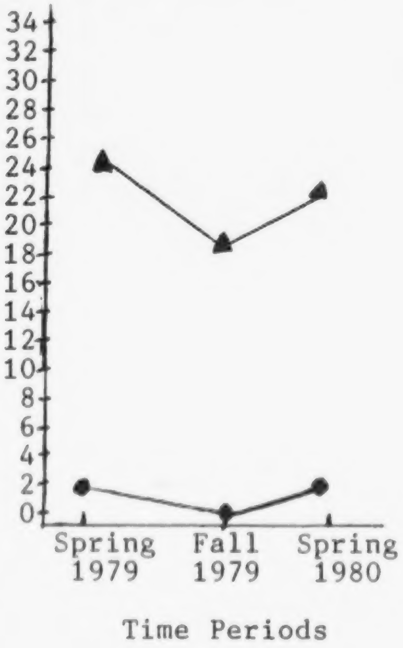
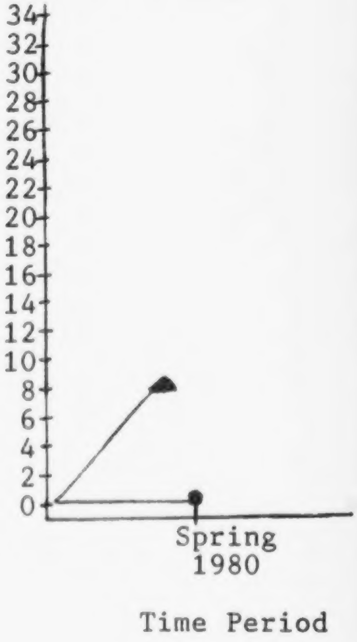


Figure 3

Modern Science Score Gaines, 1980



The Bio-Anthro unit is supplementary to an existing Biology curriculum that does have a unit in Physical Anthropology. Therefore, the consistency over time in a difference between project and comparison group performance in this strand is most meaningful as an indicator that the effects are attributable to project intervention.

Process Evaluation -- The subjective reactions of those directly involved in the project are additional indicators of the educational relevance of the project.

Teachers felt that the project was appropriate to their respective curriculum areas. They also felt that the availability of the fossil replicas for students' hands-on examination contributed to the project as a whole.

An average of 73 percent of the students across all strands felt that the project should be included in the particular course in which they were enrolled. Additionally, 68 percent of all students were enthusiastic about the laboratory approach to the study of Anthropology.

Educationally Meaningful Effects -- The project provides students with an interdisciplinary approach to the study of Physical Anthropology and in doing so supplements existing science curriculum as well as other course content areas.

For Biology and semester course students, there is the opportunity for learning based on experimental methods that is not typical of secondary science instruction in many districts. In addition to these features, Modern Science students, who usually exhibit poor performance in the sciences, did well in the program and better understood key concepts in the biological sciences.

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Head of the Faculty of Science
Barstable School, Basildon, Essex

BEAUTIFUL WAYS AHEAD

THE NEED TO IDENTIFY COST-EFFECTIVE PROGRAMS OF SCIENCE EDUCATION

Within budgets we are obliged to be cost-effective, so the answer to our theme-question is the key to all we are trying to do. But to be cost-effective we have to achieve an accepted target at such cost that the achievement is worthwhile. Scarce resources are diverted from elsewhere to our care, and we must justify what we do. We are at once into the realm of aims, those diffuse value-judgments and pious hopes that lead us onward. In the United Kingdom 'cost-effectiveness' is a dirty word: 'payment-by-results' is a phrase to be left in the past. And who will agree about the results: examination success, happiness, getting a job, or even a good job, being a good citizen, pleasure, inventing or creating beauty?

Science has found itself a place in education. We know this to be a good thing but must go on convincing others. The way we reached our current pass is not relevant; let us start instead from where we are. Jevons has said that education is a new mode of heredity, and within it science education carries exceptionally potent genes. We are expensive but "...the rewards and penalties for doing it well or badly could be breathtaking.

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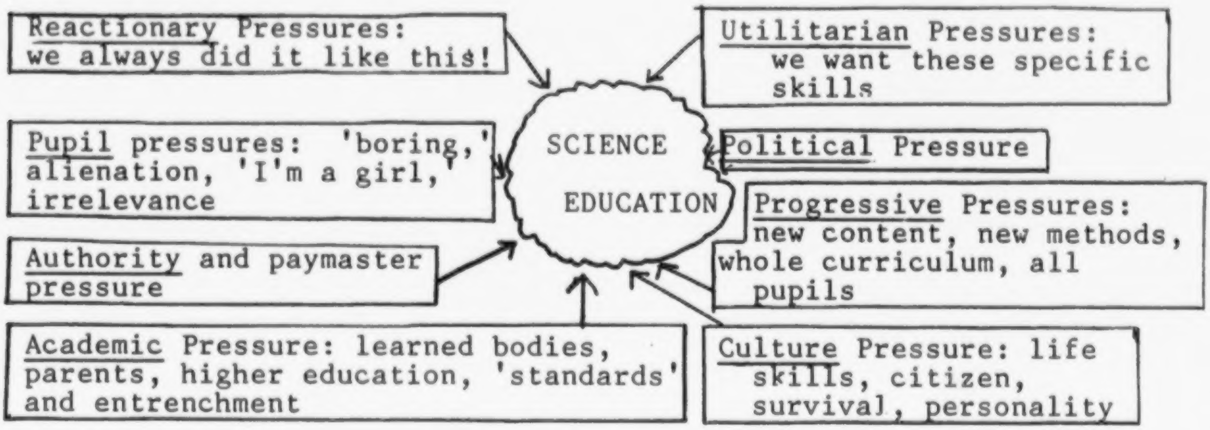
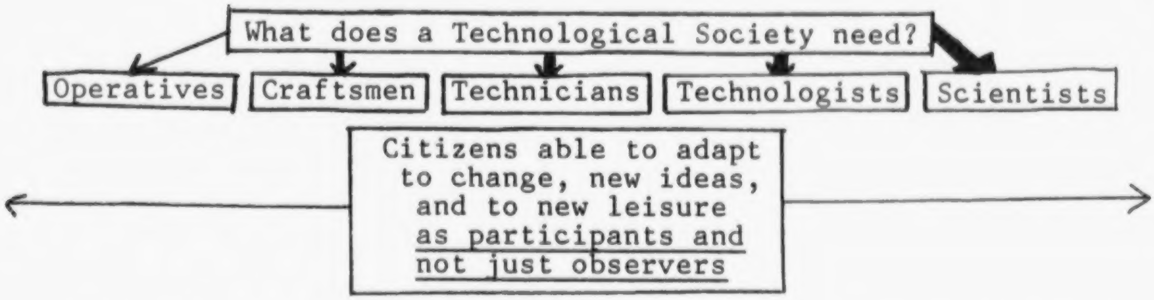
Science can easily make or break the future of mankind." (1) We know what he means. We know too that science is the basis of technology: "the rational application of science to the human condition," concerned with science but also with people, society, reason, decision-making, processes in politics and industry. (2) The facets of technology that are added to its science base are vital to my presentation.

In this paper, I address myself to the variety of pressures that beset us, consider the aims that follow from these pressures, suggest values to be placed, and wonder about routes to be sought to reach some of the targets. These routes themselves may reflect further value-judgments. Finally, I will discuss ways of assessing any achievements and hopefully show that the teacher working in the classroom, lecture room or laboratory is the most cost-effective item in our armoury. To aid the teacher to become more effective may be the outcome of our debate.

The pressures may be considered as follows:

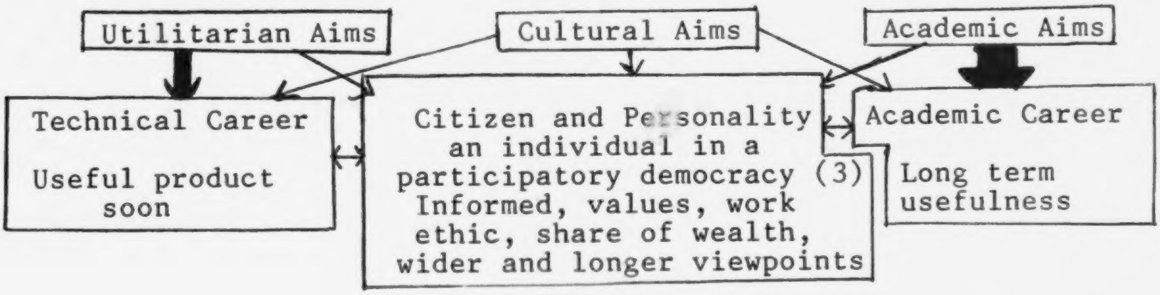

Reactionary Pressures: we always did it like this!
Utilitarian Pressures: we want these specific skills
Pupil pressures: 'boring,' alienation, 'I'm a girl,' irrelevance
SCIENCE EDUCATION
Political Pressure
Progressive Pressures: new content, new methods, whole curriculum, all pupils
Authority and paymaster pressure
Academic Pressure: learned bodies, parents, higher education, 'standards' and entrenchment
Culture Pressure: life skills, citizen, survival, personality

The figure below shows my perception of the needs of a technological society that we should consider:


What does a Technological Society need?
Operatives
Craftsmen
Technicians
Technologists
Scientists
Citizens able to adapt to change, new ideas, and to new leisure as participants and not just observers

The thicker lines represent the importance of such needs as perceived by science educators, certainly those in UK schools. We could ask if the picture is too simple, and we could discuss the percentage needs in each category.

Such a plot leads us to the following aim plan:


Utilitarian Aims
Cultural Aims
Academic Aims
Technical Career
Useful product soon
Citizen and Personality an individual in a participatory democracy (3) Informed, values, work ethic, share of wealth, wider and longer viewpoints
Academic Career
Long term usefulness

On this plan the thicker lines indicate the current preoccupation of school science teachers in the UK. It will now be clear that I refer to three classes of aim: utility, culture and academic.

In this paper I shall first discuss each of the above three types of aim. I shall then consider ways in which the different aims may be realized in the curriculum. Finally, I shall propose a provocative solution of my own.

The Academic Trap

Science education in the UK has fallen into the academic trap. The law that "...in the absence of external forces the academic always accelerates..." has applied at all levels, most harmfully in the schools. The academic pressure is allied with the specialist study of pure (separate) science.

We need the academic excellence to the highest level but, with the growth of a movement for science-for-all, the content of the old grammar school courses has remained. My concern is with the effect on the science experiences of the majority of pupils. Separate science study in Physics, Chemistry and Biology may start at age eleven, but more usually at age thirteen, and may be maintained until the school leaving examinations at sixteen. Even the examination papers for the middle and lower ability pupils will be based on the academic content.

John Head remarks that despite a long and quite successful tradition of teaching science to able students, "we have in the past rejected the rest of the population." (4)

The discussion paper of the Secondary Science Curriculum Review states that:

"Society in general and the scientific community in general pays a high price for early specialization especially when, as is increasingly the case, the demand for specialist courses inhibits adequate provision elsewhere." (5)

A meeting of teachers concerned with the Certificate of Secondary Education examination worried that "the universities effectively dictate the syllabus for O-level (the top 20%) and CSE (the next 40%)." (6)

A teacher wrote:

"... cold science ... a firmly directed path to acceptable knowledge and directly opposed to the spirit of science." (7)

Yet all the attempts to redefine 'old' subject areas in 1982 as part of the 16+ syllabus planning (the 16+ is intended to replace the two current systems and cover the top 60% of pupils) met with entrenched demands for the same content while the 'newer' curriculum areas, such as technology and electronics, led to elegant and restrained syllabus content. It appears that age and success have led to an excess of vested interest, underlining Dr. Dick West's pleas for 'parsimonious content' in the current curriculum review. (5)

How many academics do we need? Bondi suggests that it is wrong to model the education of 99% on the needs of 1%. Can these figures be right?

Psychological evidence and the testing of Norwegian students indicate that to teach some of the specialist ideas of science is a waste of effort and, indeed, may even be harmful if the pupil is not cognitively ready. 60% of pupils will not go beyond concrete thinking before they reach the age of sixteen. (8) As "pre-Newtonian thought abounds," it may be that the teaching of Newtonian Physics will lead to the loss of intuitional ideas, such as speed or energy. (9)

Yet Bruner has said that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development." I will claim that for many pupils, the academic movement in schools has lost intellectual honesty.

Is there a way out of the academic trap?

The Utilitarian Need

The designer of the favorite small car in the UK, Alex Issigonis, is given the credit for saying that "the craving to design exists from a very early age, if it exists at all. It can be encouraged by the right sort of environment but only hindered by traditional education." We shall try to imagine in what form his education must have been taken!

My early contacts with industry led me to believe that their demands, too,leaned towards the academic. If I suggested a visit of a lower ability group to a factory, I would encounter visible consternation and a raincheck. I was told that the industrial authorities did not mind what was in the syllabus as long as it was called Physics. In these days of increased difficulty for industry, I find a more enlightened attitude. Strong links with schools are encouraged and, although a preference for sixth form visits is noticed, there is a willingness to show schools what industry is about and to draw teachers into the firms for short periods of industrial experience and orientation towards industrial needs. 'Project Trident' has allowed individual pupils to spend extended periods in work as part of their school education, while the Youth Opportunity Scheme has enlarged this chance. However, the links being made with science-based industry do not often come from science teachers but rather from involvement by craft and technology teachers.

Ford, based in Essex, UK, looks for practical subjects as a pre-training entry qualification. The company asks pupils to bring along some practical work in order to check their level of creativity. (19) Pupils are assessed on such qualities as appearance, communication, intelligence, personality, confidence and interest. "This is the real world," the company asserts.

"In general," says Ron Mellor, Vice President of Ford of Europe Car Engineering, "the Japanese workforce is better educated than the English workers."

As a science teacher, I feel shame. Has my teaching fallen short in attempting to fulfill these needs? There is a telling slogan decorating the walls of Ford's Research and Engineering Centre: "If you think training is expensive, try ignorance."

"Education good, training bad," seems to be the cry of the educationalists. Our teacher-training colleges became colleges of education overnight in the 1960s. Although we should aim for generalizable training skills, I see no reason for leaving training out of school. Many pupils respond to taught skills by using them creatively -- reading and writing, for example.

Special skills may be tested readily once they have been identified -- can he/she do this/that? The recent work of the Assessment of Performance Unit in testing skills and the attempt by the Further Education Unit to set out families of needed qualities and skills -- these are endeavours to find and test the outcomes of teaching programmes. (11) (12)

Such forms of identification and testing seem to have roots in 1957 with a first grant of 20,000 pounds. Before that time everything must have appeared satisfactory.

The Assessment of Performance Unit has sampled randomly over most of the UK, using a set list of items suggested by current syllabus content and the views of many teachers. The results are intended to act as a datum line to test future achievement in terms of the tests in 1980. Of course, to make future tests one has to assume a consistent set of aims, and the matter is fraught with difficulty. Some conclusions on provisions do emerge; at age 15+ the chosen targets are better reached by having more apparatus, more technical support, and better or more laboratories. While this is hardly a surprise, it is surprising to reach the tentative conclusion that the class size has little bearing on pupil performance. The maximum number of pupils permitted in a technology class in the UK is 20, and in science classes the maximum is 30, and 20 in Scotland.

The recent Department of Education and Science paper, "Science Education in Schools," states that for the lower-attaining pupils the application of science and its relevance to the outside world should dominate fourteen through sixteen age-range teaching. The Association for Science Education has produced a list of science skills based on the work of the Further Education Unit. The pattern is one of core plus vocational plus job-specific items, applicable at seventeen and beyond, but being introduced into schools now at age fourteen in newly-designed courses that go well beyond traditional science. The implementation of such ideas is usually achieved from other curriculum areas.

I must issue a warning. All the creative curriculum work in this area comes from bodies that have not been linked to school science, but are more concerned with the world of work, further education (beyond sixteen and out of school) and the work of school craft/technology workshops. Sensing a vacuum caused by the poor teaching of science, these areas have moved towards the academic more than has been their custom. As an example we may take the work of the City and Guilds of London Institute, a traditional source of courses and examination for further education. Their Foundation Courses in Science Industries (ref. 687) link science content to a core of basic life skills: work, communications (written, spoken, numerical), career guidance and leisure. Even more of a threat to school science is their 'Background to Technology' course, comprised of over 87% Physics with an addition of tool construction and materials technology. The whole course is based fully on industrial processes. This may be the way to teach Physics, but what will happen to academic Physics courses in the light of this new attraction? It is our negligence that has left the gap now being filled by these soundly-based courses which cater to the enormous range of pupils who do not need the more traditional fare.

It is ironic that the Inspectorate (Her Majesty's Inspectors or HMIs) refer to the strong links between science and technology seen in some schools, and then comment in the same paragraph that "an enquiry into the range and effectiveness of existing links between industry and science teaching was outside the scope of the (major and fullest in recent years) survey." (15) The Industry link is crucial to science education.

The Cultural Aspect

The science-for-general-education movement has had as many setbacks as the science-for-all and the industry-link groups. The most glaring example of these, and a case of political interference, is the reaction of the Secretary of State for Education to the 16+ criteria for Physics. After much debate, these criteria made reference to technology, practical skills, and the social and economic effects of any applications. The latter point has been denied us, the first two enthusiastically endorsed. The Physics world waits for the next step. (16)

I will link this to the 'whole curriculum' movement, which wishes to concentrate on the whole learning experience of the child rather than dividing it up into units, one of which being 'science.' An element of transfer of skills is apparent in this approach. At North Westminster School in London, England, the introduction to 'Science, Technology and Society' reads:

> "An understanding of science and technology and their social, moral and political implications is essential to all women and men (sic) in the complex society in which we live. For schools to accept that there exists a large group of pupils for whom the essential features of science and technology are too complex to be understood is a dangerous error. It is already resulting in a situation where the majority accepts scientific/technological change in an apathetic, uninterested and uncomprehending way, leaving value judgments to the cultural elite. This elite is itself educated on a narrow, academic, 'pure' science." (17)

At Kingsthorpe School, Northampton, England, and as part of a total curriculum, all science teachers teach technology -- structures, mechanisms, electronics, pneumatics -- in a curriculum emphasizing applied science and everyday topics. (18)

The HMIs have listed eight areas of experience which welded together could form a complete curriculum -- an attractive idea. (19) But to link the 'old cold academic specialist' science to such new 'open' ideas that appear to be demanded by technology requires new skills and new resources. The Science in a Social Context (SISCON) Project attempts this and deals with the responsibility of the scientist for its potential success --

"hoping that science staff may teach their subject in a way that their pupils/students have some awareness of its social implications." (20)

But is this sort of science teaching what we mean when we talk of cost-effectiveness?

Aims and the Curriculum

Let us consider cost-effectiveness.

If we wish for an academic elite to make great advances in basic research for technology and the development of that technology, then we already have the tools to do the job in a narrow way. We can put a selected group of pupils at some suitable age into special schools, set them on more creative work than is currently allowed and permit their natural abilities to run free, aided by skilled teachers and good resources. This seems too obvious and too popular in circles where porridge words like 'standards' and 'excellence' are bandied about. Undoubtedly, it would deliver an acceptable output in the eyes of some advisers. It is very tempting.

If we wish for a Japanese-style workforce -- supposedly able to deal with problems on the spot without reference to hierarchical management -- or if we want large numbers of technicians, then the way ahead is equally clear. We must go for specific applications in a high-intensity course geared for current industry with relevant basic science skills, and hope that these generalizable skills are adequate for whatever the future may hold. This may not be the job of the science staff, for others have made their claim on this side of the work. Judgments on the need for retraining, or on the earlier and earlier retirement of a workforce with superannuated skill, may be involved. But this is not science as currently taught. It may not even be education.

We may wish for a generally educated public with a wider range of skills; to manage, say, decimalization of coinage in one day -- something that actually happened -- or to make judgments on the rightness of small wars -- the Falklands or Grenada conflicts, for example. Science has a part to play in the process of opinion-forming -- on topics like pollution, weapons, new technologies, new ways of living, even education for the unemployed. Heimler regards the present as the start of a new age for the 'is work so marvelous?' theorists. He suggests that for life in the twenty-first century, school subjects will have to be chosen more carefully and children will not need to know the great rivers of the world or follow any pseudo-academic disciplines, but instead will have to learn a great deal about their own capabilities and limits. (21)

All pressure groups will answer differently. We may seek any target aim but will encounter many problems if we attempt to check on the achievements of all but the most disassembled objectives. The term 'cost-effectiveness' seems meaningless.

Science fiction has already rehearsed the scenarios of the future. Kornbluth's 'Marching Morons' pictures a world in which a socially conscious elite entertain and feed a mindless population. Forster's 'The Machine Stops' is a world of elite without technical support after the system fails. In the Star Wars galaxy there appears to be no technical base to a technical culture. Worlds are imagined in which no scientists are allowed to live, where all the labor is carried out by machines, and in which all the problems of mankind do not exist. To look at the future of science education in terms of cost-effectiveness is to make projections worthy of the best and the worst of science fiction.

Beautiful Ways

I put forward a solution. I call it the 'Beautiful Way.' Suppose that we take aesthetic rather than economic, social, academic or practical aims. We are still on difficult ground. How about the ultimate aesthetic concept, human survival. "Science can make or break mankind." It is testable.

Schumacher said, "Nothing makes sense unless its continuance for a long time can be projected without running into absurdities .... There cannot be unlimited generalized growth.... It is the denial of wisdom." Wisdom is an aim indeed. G.K. O'Neill's vision of the application of science and technology to the study of possible space cities may be elitist:

> "If you put 10,000 hardworking and highly-motivated people in a situation where they have available, unlimited energy and a great source of materials, they will soon find a way to build themselves very attractive places." (22)

Although elitist, it is certainly beautiful. It excited students formerly put off science by the images of war and pollution. Conquest of disease and hunger needs science-plus, the plus being an awareness of the rights of others. The third world watches us, and our awareness of their problems can become part of teaching. Pollution and war can be fought by the great and beautiful uses of science and technology.

Put off by science? Yes, pupils by the thousands damn science for its demonstration of their failure and of its uselessness, as they see it. Wouldn't it be beautiful to allow pupils to succeed , enjoy, make, and invent? I have seen the least of them do this in the right situation. It is the 'high' of science teaching when that pupil suddenly says, "Oh ... yes."

I really enjoy teaching, but never more than when I have managed to make pupils love their learning, when they have realized that it is up to them to learn for themselves. Perhaps cost-effectiveness lies in teaching that learning is fun. Only a teacher can lead the way into this. But year by year, teachers are written off as outmoded. "Teachers were written off at the advent of television, language laboratories, programmed learning, the film projector, radio and, no doubt, by the first cave painting," says Ted Wragg, referring to the micro. (23) He adds that in each case the wonder-machine has eventually taken its place as part of the repertoire of skillful teachers rather than as a replacement for them.

Teachers may not know best, may need the guidance and advice of others because they are too close to the pupils, and may need persuasion and arm-twisting to alter antediluvian ways, but they do the job better than any conceivable alternative. They can use their human intuition to diagnose faults in a computerized system by identifying the symptoms. Science with a human face needs the human face. Perhaps cost-effectiveness is to be found in raising the effectiveness of the teachers. The aids that technology can provide cost relatively little in comparison with the cost of a teacher, but they may raise efficiency out of all proportion to that extra cost.

If well-supported teachers joined hands with the usurping technologists -- the social scientists and the visionary futurists looking at possible worlds in an attempt to achieve a beautiful curriculum -- then we would need to satisfy many of the pressure sources. We would have to convince parents that their children's chances in life would not suffer, possibly even decoupling education from class consciousness. Industry would need to be persuaded that such a curriculum would serve it well. The darlings of content left with us from the nineteenth century, together with some more recent additions, would need to be removed to leave us with a parsimonious basis for thinking about the future from 1984 onwards. Whole fields of astronomy, geology, meteorology, electrnoics, health and communication, together with application, creation, art and design -- all linked to real life -- would put us into a new world. Perhaps the change of view from the job-ethic to the free-creative-time, enforced by unemployment, which we could call leisure, will indicate the way ahead. To be cost-effective, the science of the future may have to be less blinkered by utility and instead shine through its own excitement and beauty.

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Discussion: Cost Effective Science Education

Plenary
Jon L. Harkness, Rapporteur

Dr. Sitkoff was asked if students were involved in casting the epoxy replicas of archaeological samples used in the Stones and Bones program. He responded that students were involved in the production on a volunteer basis. They worked under guidance of paid university students and volunteer museum staff.

Sitkoff was asked if Stones and Bones was available in Spanish edition, but it is available only in English.

Sitkoff was asked if the Stones and Bones anthropology unit is displacing something in the science curriculum and, if so, what? Also, inquiry was made about goals of Stones and Bones. In response, he clarified that Stones and Bones is intended to compliment, not replace, existing courses in general science or biology. It may be used as an exciting alternative unit of study at a cost as low as $18.00 per class. The program was depicted as pursuing problem solving goals (i.e. students formulate and pursue hypotheses), which is a refreshing change from didactic processes.

Michael Williams was asked how economics applies to teaching. How is the product measured? He asserted that the question of cost effectiveness for science is a false question.

Sitkoff interpreted cost effectiveness in terms of response to budget cuts. He cited a need to find innovative ways to maintain quality science programs during times of declining resources.

James Robinson observed that shrinking dollars can be expected to result in pressure to show the effectiveness of maintaining expensive laboratory based science instruction. He asked, "Are we prepared to defend this practice in terms of its continuing cost?"

A question was raised from the audience concerning whether it is cost effective to encourage females to pursue science. Sitkoff noted that progress seems to be made in this area; teachers and counselors increasingly encourage females to pursue science.

Group I
Jean Price, Rapporteur

There are two different areas of cost effectiveness:

1. Cost effectiveness at a local level

2. Cost effectiveness at a national level

In England cost effectiveness at a local level is not as meaningful as in the United States, but in both countries cost effectiveness is important at a national level.

How can cost effectiveness be measured?

The money for education is limited, and competition for this money is increasing. If the amount of money available for education is to decrease, then it is imperative that the money is used efficiently.

$$\text{Efficiency} = \frac{\text{amount of learning}}{\text{cost}}$$

How do we measure the amount of learning?

Is it by a) achievement tests,
b) skills acquired,
c) quality of life,
d) assessment of performance.

(The Assessment of Performance Unit has established a datum line to test the performance of future pupils in terms of 1980 tests.)

We are trying to produce scientifically and technologically literate pupils who can compete and function in the world outside. How do we measure this?

Can the amount of learning be measured by pupil numbers? Girls are often "switched off" by Physics. This, in my opinion, is a waste of talent and not cost effective.

Competition for pupils and resources exists between science and technology. An overlap of content and process exists between these subjects. Money which used to be available for science is not channelled down other pipelines.

In England a dichotomy exists between the government agencies* and science teachers. Money is made available by these agencies, but conditions are attached to its use. In the United States a dialogue exists between the local community and education. In order to get an education program "off the ground," support from local industry, in terms of finance and personnel, is required.

Suggested Research

Research is needed to clarify some of the issues raised. (Research could be in the form of hard data or case studies, etc.)

A. Science teaching is more effective in a laboratory than in a classroom. Laboratories are expensive to provide and to run. What research is available to support these hypotheses?

B. How efficient is communication within science education? How can the efficiency be improved? Who is responsible for this communication?

If professional associations, such as N.S.T.A. and A.S.E., have a role to play through their publications and meetings, this role must be a policy/action role.

Lastly: in the third world there are even more problems of cost effectiveness -- should the A.S.E. and N.S.T.A. involve themselves?

**Government agencies: Dept. of Industry, Manpower Services Commission, Technical Vocational Education Initiative (TVEI) and Dept. of Employment.

Group II
Gary Appel, Rapporteur

We raised many questions.

1. How do we assess cost effectiveness?

2. Who are we considering when we speak of cost effectiveness?

    Parents?
    Children?
    Teachers?
    Politicians?
    Researchers?
    Industry?

3. We clearly have many clients for science education. Who is to define cost effectiveness?

4. How do we measure effectiveness without agreeing on what is our "vision"?

5. How do we assess non-monetary effectiveness? What will be the cost to human survival of not teaching about "peace" and conflict resolution?

6. What will be the effect of the private sector's heightened involvement in education? Are we taking education away from the educators and giving it to the industrialists? The vacuum created by the reduction in state funding for education, that is now being partially filled by the private sector, has great public policy implications. Support comes with strings attached

and is motivated by self-interest.

7. How can community involvement, as an instrument of cost effectiveness, be increased?

8. How do we economically improve teaching practice? Do we train "pioneer" teachers and depend on them to transfer new practices to others?

9. How do we enhance teachers' skills instead of downgrading curriculum, e.g., teacher proofing?

10. How do we face the policy makers' demand for hard data when so much of what we as educators are all about is affective?

11. If we only teach cognitive science, what do we lose? It was felt that governments suppress the affective teaching domain in science. They want us to ignore the cultural and social implications of science in our instruction.

Summary

We can't measure effectiveness until we decide what we all want. We are skeptical regarding the continuation of old models.

We can talk about costs, but we can't talk about effectiveness without talking about purpose and constituency. Most of all, we need to define a sense of direction. Where are we going, and how are we going to economically and effectively get there?

Group III
Geoff Oliver, Rapporteur

1. The concept of cost effectiveness is only applied to areas that are seen as of less than primary importance. They are rarely applied to defense, for example.

2. National governments, however, need to have quantifiable costs of implementing different strategies, for example, of giving a science education in depth to 50% or a broader view of science to 100% of the population.

When the politician or planner has this information, he can make his decisions, and the teacher then inherits a budget that has been decided for him. He has little direct say in philosophical or political stances taken, and in general the schools cannot decide on total allocation of cash inputs, e.g., expenditure on staff or on buildings.

3. While cost can be quantified, effectiveness is exceedingly difficult to assess. Previously, the aim was to produce an

academic elite of scientists and technologists. Now we are looking for effectiveness in generating a scientifically educated and aware citizen. The emphasis can change and with it the notion of effectiveness.

In any consideration of effectiveness, the teacher is the prime factor. The most influential method of increasing effectiveness in education is to improve the effectiveness of the teacher. The design of curriculum materials and methods that maximizes the possibilities of teacher effectiveness is the second priority.

4. In both the U.S. and U.K., teachers now suffer from a problem of low morale and education, of a drop in input of cash and resources, both of which are exacerbated by a drop in the number of pupils in the schools. The value placed by both administrations on education and other social support systems further increases pressure on teachers in schools.

Providing support systems for teachers is an essential way to improve motivation and morale. Curriculum workshops can give time to take an overview and to exchange views, ideas and problems with colleagues; this can be an important feature in these strategies for improvement. Teachers, too, might adopt some of the methods of the industrialists -- who traditionally work with a background of job insecurity -- in that they should: publicize their worth and take more demanding stances when applying for resources (often by being more self-critical and by looking for improvements within current resource levels as well as asking for a greater resource share.) Effective strategies would also take account of research findings and apply them in the classroom.

5. Finally, education has too often looked for short-term solutions, leapt on fashionable bandwagons and suffered from a lack of confidence and long term vision. Science educators must adopt a long term aim distilled out of a series of basic criteria and objectives, go to the outside world and seek the views of industry, parents, politicians, etc., and then (while adapting their views) keep to the fundamentally consistent pattern of the long term strategy.

Group IV
Art Farmer, Rapporteur

Definition of Cost Effectiveness

- Can cost effectiveness apply to science teaching?
- In dollar terms only or does it include teacher time?
  a) Can teachers be released from non-teaching duties

to compensate?

* Should include: people, buildings, supplies.

* To free teachers, cost effectiveness should include the necessary support system for teachers -- secretaries and technicians.

Aims

What are the Desirable Goals?
Wide and Diverse.

Are they dictated by high tech or are they to include cultural and utilitarian (survival) values? Could we agree with industry, or should a consortium decide?

How about state science frameworks?

Are the goals different for different populations?

Wat is the quality of the experience.

Must the means dictate the aims?

Means

* Who develops the means? Teachers or administrators?

* Experiment vs chalk talk.

* Transferable programs -- district to district.

* Making use of unused resources -- recycling, stock control.

* Fuller use of year -- conflicts with recuperation time and summers off motivation.

* Different costs for different means -- who controls or decides?

* Teacher Efficiency

* Should be developed by teachers for teachers.

* How will it be packaged?

Impact of text publishers.

ASE publishes some of its own materials.

Accountability

* Will be demanded by public.
Can computers do a better job?

* Who does the research?
Ivory tower colleges or teachers?
These two should merge.

PART II

THE APPROPRIATE USE OF HIGH TECHNOLOGY IN THE CLASSROOM

Papers by:

Audrey Champagne
Mary E. Linnington

Discussion

Audrey B. Champagne
Learning Research and Development Center
University of Pittsburgh

Plan First, Buy Later: A Researcher's Look at Computers in Schools

A priority action for every school district is the formulation of a comprehensive plan for the integration of the computer into the district. The function of the comprehensive plan is to prevent the district from reacting in haste to the many external pressures on the educational community to incorporate computers into the schools. And make no mistake, the pressures are great.

The computer is becoming a pervasive force in American life. It has revolutionized the conduct of business, industry, government and the military. Computers are invading our homes and our schools. Parents believe that computer literacy is a necessary condition for gainful employment, and they want their children to graduate from high school as computer literates. Business, industry and the military project ever increasing needs for individuals skilled in computer applications. The many commissions studying precollegiate education claim that the failure of the schools to prepare their students to cope with technology is a threat to the nation's economy, military strength, and democratic way of life. Along with these social pressures are the economic selling pressures of the computer hardware manufacturers urging schools to buy now!

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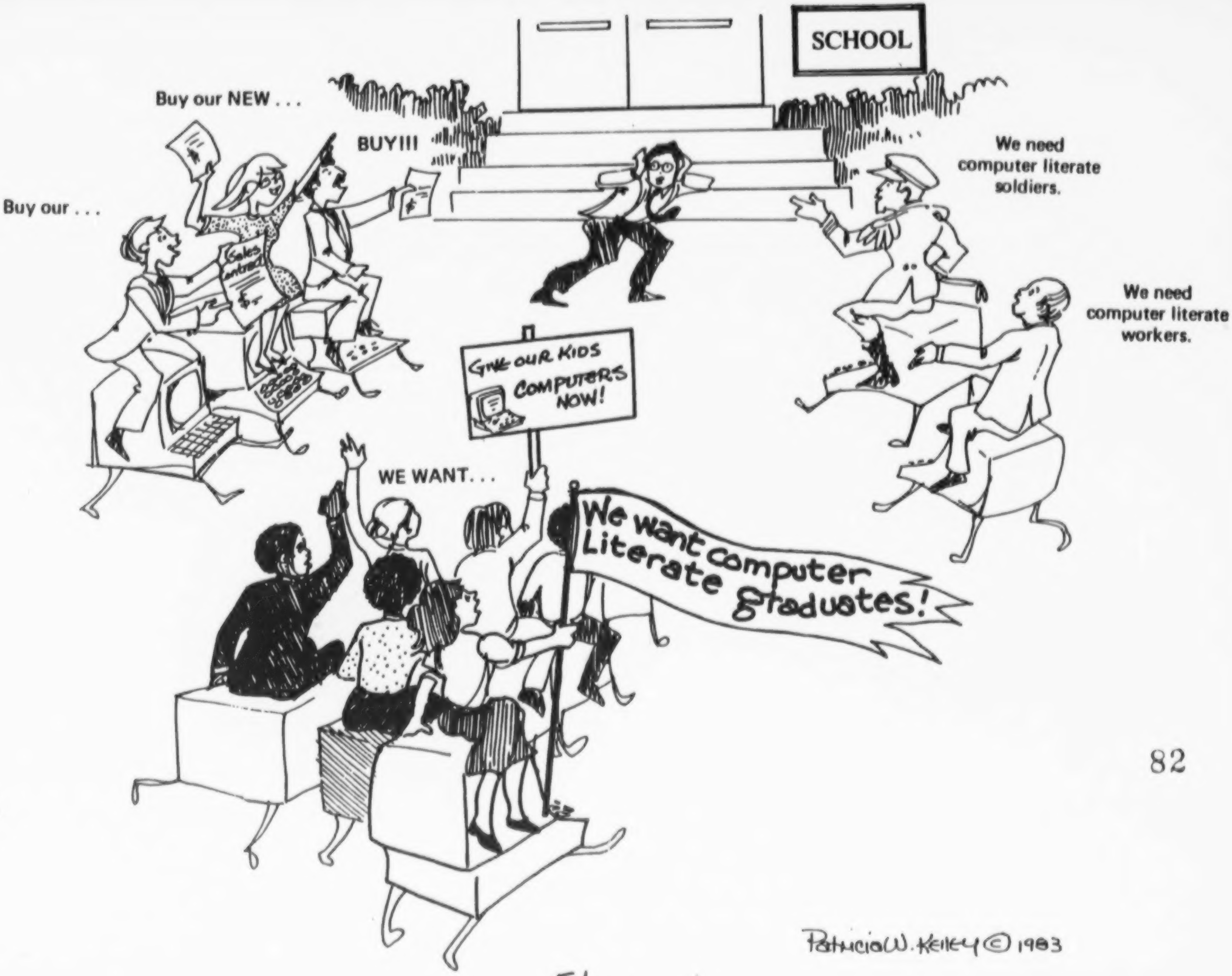
Figure 1


SCHOOL
Buy our NEW . . .
BUY!!!
Buy our . . .
Sales contract
We need computer literate soldiers.
We need computer literate workers.
GIVE OUR KIDS COMPUTERS NOW!
WE WANT. . .
We want computer Literate graduates!

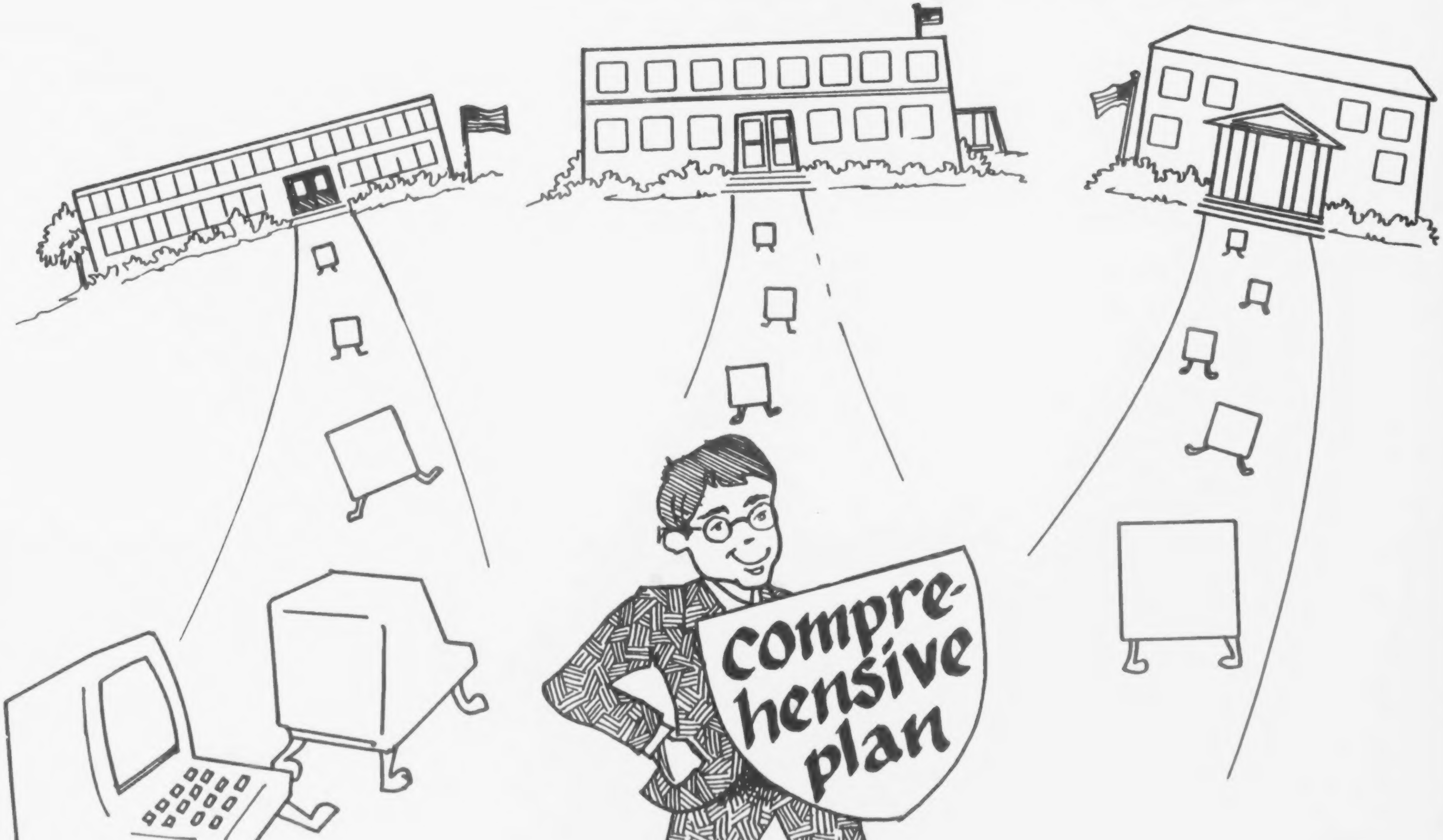
Patricia W. Kelley © 1983

F/ 1

Out of self-defense, schools are making hasty computer purchases. The consequences in many cases are dire. Consider the case of a district that purchased eight million dollars worth of microcomputers to improve its instructional programs. After the purchase, the administrators learned from their teachers that no good computer courseware was available that would run on the machines. In far too many districts, computers sit cold and quiet, locked in closets, because they were purchased with no comprehensive plan for their use. With the rapid developments in computer technology and the cold, hard reality of the economics of courseware development, the probability is high that schools will experience yet another technology fiasco. The computer may well join the motion picture projector and the teaching machine as examples of technological innovations, capable of revolutionizing learning, that sit seldom used, gathering dust. We are told the promise for computers in education is great -- the present reality is sobering.

The district with a well-informed, comprehensive plan can avoid many of the pitfalls placed in its path by the current social pressures and the ambiguities of the future of computers (Figure 2). This paper is about planning for computers in the schools. It includes: a general description of an approach to developing the plan; some basic information about computers in educational systems, and a discussion of problems and issues that will be encountered in developing the plan.

Figure 2


compre-
hensive
plan

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An approach to formulating the plan

The process for formulating the comprehensive plan is presented in the form of a flow chart. Flow charts are used by computer programmers to plan computer programs -- the use of the flow chart format will convey a flavor of how people who work with computers address a problem. The goal statement is at the top of the flow chart (Figure 3). The goal is a comprehensive plan for integrating the computer into a school district. The formulation of the plan involves two basic actions: gathering information and setting priorities. Three kinds of information are necessary: information about possible uses of the computer, information about the district's priorities for the improvement of education and administration, and information about the district's resources.

The first step in setting priorities is to determine which of the district's goals can be achieved using the computer (Figure 4). For example, an educational priority may be to improve the computational skills of elementary students. A possible use of the computer is to provide drill and practice to achieve the desired improvement. Another district priority may be to reduce the cost of providing laboratories for secondary science while maintaining the quality of the program. Computer simulations of science laboratories are a possible way to meet this need. A third district priority might be to reduce food waste in the cafeteria. A computer food management system is a possible way

Goal: A Comprehensive Plan for Integrating Computers into a School District

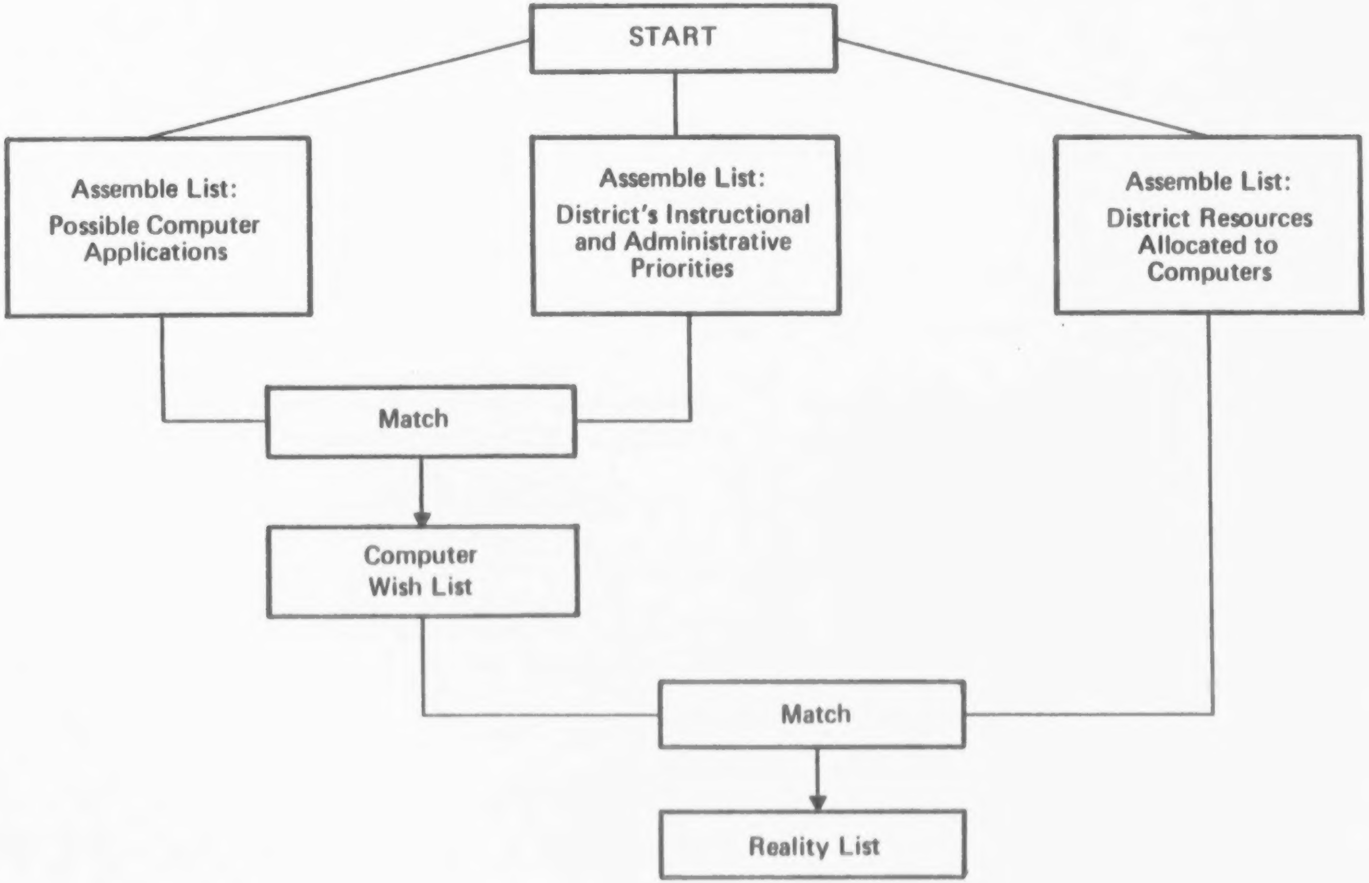

START
Assemble List: Possible Computer Applications
Assemble List: District's Instructional and Administrative Priorities
Assemble List: District Resources Allocated to Computers
Match
Computer Wish List
Match
Reality List

Figure 3

Figure 4

DISTRICT PRIORITIES

- IMPROVE ARITHMETIC SKILLS
- REDUCE COST OF SCIENCE LABORATORIES
- REDUCE FOOD WASTE IN CAFETERIA

POSSIBLE COMPUTER APPLICATIONS

- INSTRUCTION
  - DIRECT INSTRUCTION
  - DRILL AND PRACTICE
  - SIMULATION
  - PROGRAMMING
  - USER APPLICATIONS IN SUBJECT AREAS
- INSTRUCTIONAL MANAGEMENT
- ADMINISTRATION

WISH LIST

- ARITHMETIC DRILL AND PRACTICE FOR GRADE 6
- PHYSICS LABORATORY SIMULATIONS
- FOOD MANAGEMENT SYSTEM FOR CAFETERIA

to achieve this goal. The list that results from this process is the district's computer "wish list." This list shows possible ways in which the computer can help the district meet its goals for school improvement. The next step in priority setting is to decide which of the possible computer applications the district has resources to initiate. The list that results from this process is the "reality list." This is the point in the process at which the difficult decision making begins because a district's resources are never sufficient to achieve all of its goals for improvement.

Enumerating the district's priorities for integrating computers into its instructional and administrative functions is only the first step in the generation of the comprehensive plan. The plan must also include the sequence and the steps for implementing the program along with projections of the district's future computer needs.

The planning process is, of course, more difficult than the foregoing description indicates. It is also fraught with ambiguity and uncertainty. What follows is some information that should be helpful in the planning process, and a discussion of some problems and issues likely to be encountered. The paper is organized around four topics: computer information management and assessment, computer application in education, computer literacy, and time.

Technical information, management and assessment

Planning for a new technology produces considerable anxiety among educators and laypersons because the planners are not knowledgeable about the technology. While becoming informed about computer technology seems a formidable task, in reality it is not. Learning about computers is simple when compared with learning about the basic processes of schooling -- teaching and learning. The point is that the basic principles of good instruction have not been changed by the introduction of the computer. Neither have the principles of good educational administration. The really difficult issues have to do with effective instruction and administration, not with bits, bytes or roms and rems.

There are three problems related to computer information: the quantity, the quality, and the technical nature of the information. Vast quantities of information are available -- more than can be absorbed in a short time. Thus, the need-to-know principle is useful. Begin the planning process, and as gaps in knowledge become obvious -- fill them. Coping with the technical vocabulary and information is a threat to many educators. With respect to technical vocabulary, take the attitude that the user is responsible for communicating unambiguously. If someone uses an unfamiliar technical term, ask for a definition. If it isn't clearly defined, go elsewhere for advice. A glossary of computer terms or a modern dictionary is a helpful guide. The basics of computer technology can best be learned by taking a survey course at a local junior college or university. The technical information is probably the most intimidating, but a great deal of technical knowledge is not required for making intelligent decisions about computers. After the relevance of technical knowledge has been put into perspective, the next steps in the planning process can be undertaken with confidence.

To cope with the problems of the quantity and quality of information, carefully organize the collection of information and make stringent assessments of its value. Scrutinize the credentials of the purveyors of information. If the person giving information about a particular system is trying to sell it, judge the information accordingly.

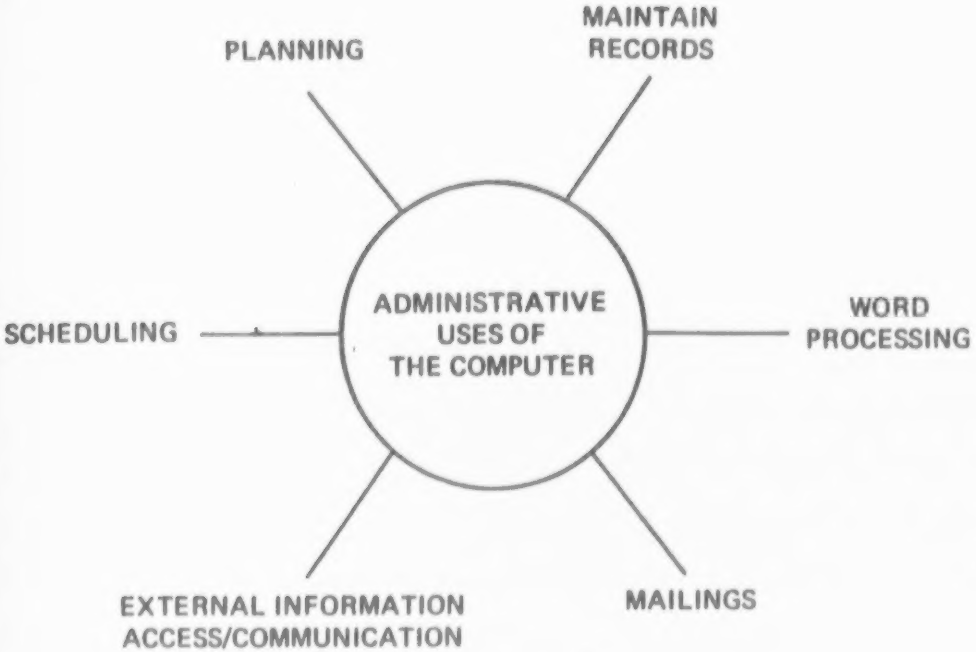
Computer applications

There are many ways to organize the information gathering stage of the planning process. It is useful to organize the information around categories of application, such as: administration, instruction, and instructional management.

Computers have the capability of making administrative tasks easier and more efficient. Some administrative uses of the computer listed in Figure 5 include record maintenance, planning, scheduling, external information access/communication, mailings, and word processing.

The record maintenance function is useful in three administrative areas: (1) library management, (2) expense management, and (3) staff and student file maintenance. The advantage of using a computer is that information can be quickly and easily changed or added, and it is always possible to call up a current copy. Listings and sublistings of records may be obtained readily at any time. In the library, the computer keeps track of what books are in, what books are out, and who has them. The computer can compose sublists; for example, it can print lists of which books have the highest circulation or what books are overdue. As a keeper of the budget, the computer can keep a running total of operating expenses and check it against available resources. As an information reserve of staff and student data, the computer can store and easily access a comprehensive file of all personnel and students. Records stored on the computer can be used to print out the payroll, report cards, and student transcripts.

Computers can also be instrumental in planning. Data stored in the computer can become the basis for projecting needs. Consider an example of cafeteria management aided by computer information storage. If there are two choices in the cafeteria lunch line (grilled cheese sandwiches and hamburgers), the computer can be used to keep track of student preferences. The comprehensive record of student preferences over a period of time


ADMINISTRATIVE USES OF THE COMPUTER
PLANNING
MAINTAIN RECORDS
SCHEDULING
WORD PROCESSING
EXTERNAL INFORMATION ACCESS/COMMUNICATION
MAILINGS

can be used as a basis for planning how many servings of each to prepare and how much food to order.

Scheduling has always been a difficult job. The computer can make the task easier. Once an appropriate program is available, the computer can quickly schedule a thousand students for seven classes a day -- complete with teacher, room, and student timetables, student master lists, etc. The computer can also be used to schedule buses. Computers are "fast" at this type of information processing if they have been well programmed.

The information access function of the computer will become increasingly important. An information bank is useful because it consists of a comprehensive source of information. An example of an information bank is the Student Guidance Information Service (Noonan, 1983), a compilation of career descriptions and training information for several thousand careers. The availability of this information is useful to guidance counselors and teachers of classes on career planning.

Computerized mailing is a real time saver. The computer can access a mailing list (as a whole or selectively) and print out individualized letters and envelope labels. For example, if a letter is to be sent to all parents whose children are involved in the chorus, one form letter can be typed and the corresponding list of addresses selected. On command, the computer can print the stack of individualized letters and address labels.

The word processing capabilities of a computer are invaluable. The word processor eliminates retyping. Forms and reports can be easily edited and adapted by entering only the changes and additions. A clean copy is always available from the printer.

The administrative applications of the computer are quite straightforward. Decisions about specific implementation should be based on the quality of available software, its degree of user friendliness, the amount of memory required to store information, and issues of cost effectiveness.

Currently available systems for instructional management (guidance) are also quite straightforward and overlap with administrative uses. Computer applications for instructional management, while now quite mundane, have the potential to develop into a powerful tool to improve learning. Computerized learning management systems are still in the developmental stage. As these systems are conceptualized, they will be used to test students, identify specific gaps in their understanding of a topic, develop a sequence of instruction, and then teach the student. This facility may make truly individualized instruction possible and is an example of an instructional use that appropriately exploits the unique capabilities of the computer. However, such systems are a long way off.

Instructional uses of the computer include drill and practice, direct instruction, and laboratory experience via simulations and applications. Many programs providing drill and practice are currently available and used in schools. The quality of these programs varies. The quality of many is poor. Notable is the inappropriate use of reinforcement. Students often get more reinforcement for starting up the program than they do for getting the right answer to a question. Consistent with behavioral theory, the students spend more time starting up the program than practicing. There is no doubt that using the computer is more motivating than the usual work sheet. However, informal evidence is accumulating that the initial motivation wears off quickly.

Another issue relevant to electronic drill and practice relates to the appropriate function of the computer. Using the computer for drill and practice underuses its capacity. Such activities exemplify the use of a computer to do something workbooks do just as effectively.

In contrast, the use of the computer for simulations and direct instruction is more appropriate for its capabilities. There are, however, few examples of these programs available to schools.

Word processors, text editors, and spell checks are important computer tools for creating written texts, and are therefore useful tools for teaching composition in English classes. Computer graphics programs enable the developing artist to create designs and animations quickly and thus facilitate the learning of graphic design. Software is available to effect solutions of higher order mathematical equations and complex chemical problems. These programs are useful adjuncts to traditional instruction in mathematics and science. The list of computer applications in the subject areas continues to grow, as does the list of user applications in business and industry. Young people must be taught to effectively use software that others have written. The ability to use available software is one facet of computer literacy.

Computer literacy

What is it? Who needs it? What are the school's responsibilities for developing it? Figure CL1 depicts four facets of computer literacy: user competence, understanding computer mechanics, computer capabilities, and the social impact of computers. A major problem related to computer literacy is that there is no explicit agreed upon definition for it. Many equate computer literacy with the skill to program the computer. Others assume that computer literacy means programming skill plus some understanding of the three facets. These differences in meaning attributed to the term produce considerable miscommunication. Thus, an essential step in the planning process is a common public definition of computer literacy. An

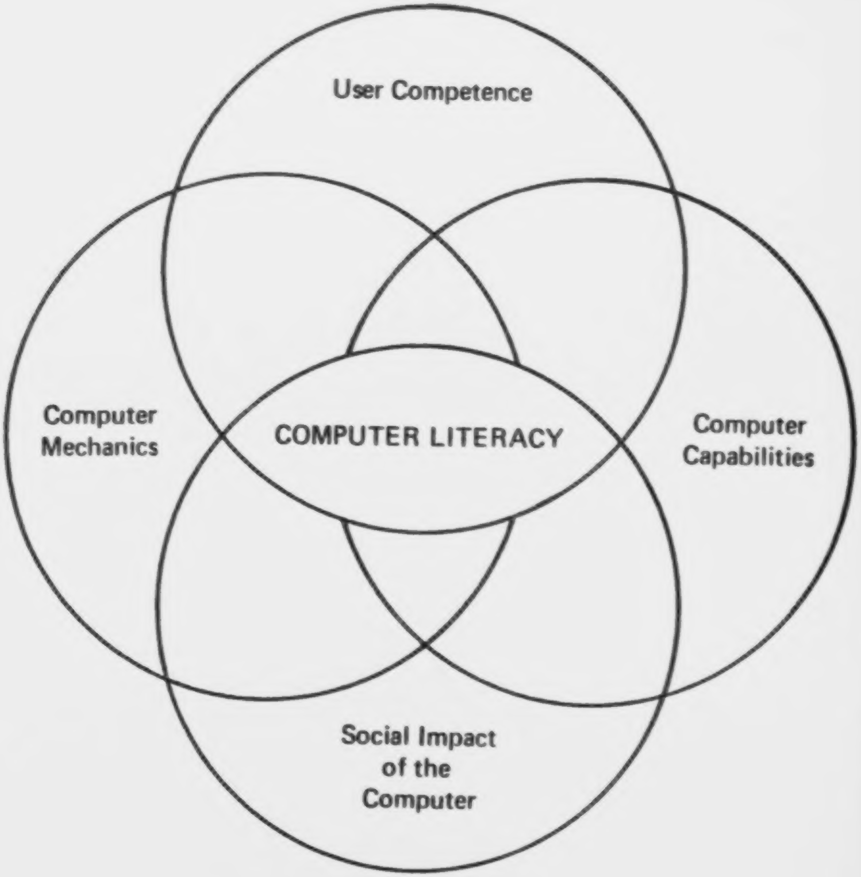

User Competence
Computer Mechanics
COMPUTER LITERACY
Computer Capabilities
Social Impact of the Computer

Figure CL1. Facets of computer literacy.

important part of that definition is the explicit statement of the levels of user competence that the school system expects to develop.

User competence is at the top of Figure CL1. Training competent users is the primary motivation for bringing computers into the education system. Planning for computer education programs requires a thorough understanding of the knowledge, skills and attitudes that underlie different levels of user competence. Figure CL2 sketches out the knowledge, skills and attitudes that comprise different levels of user competence. The knowledge and skills required to be a successful user depend on both the software and the complexity of the machine the user is expected to master. Most software that runs on a single purpose machine requires only that the operator can read and follow directions. An example of this lowest level of user competence is the ability to operate a bank machine. Slightly more skill is necessary to operate software on more sophisticated multipurpose machines. At this level of competence, the user must be able to activate the computer: plug it in, turn it on, load the program and follow more complicated directions of the software. This is the level of skill required to operate most business computers for word processing and accounting. A significantly higher level of knowledge and skill is required to write programs that use the computer to solve problems, play games, do accounting, etc. Programming requires special technical knowledge -- knowledge of technical terminology and programming languages -- and

USER COMPETENCE

SOFTWARE	MACHINE	EXAMPLES	KNOWLEDGE-SKILL ATTITUDE
Super-Simple User Friendly Tamper Proof	Single Function	Commercial-Consumer Banking Machine Ticket Dispenser	Confidence Read Do
User Friendly	Mini Micro Single Function	Word-Processing — Composing and editing text Cash Registers Accounting Systems Navigation Systems Games	Plug it in Turn it on Load It Log On Keep/Delete Files
Machine Software		Write Programs	Design Programs for Personal Use
User Friendly Limited Access Machine Software	Mini's Main Frames Systems	Airlines Reservations Systems Banking Systems Academic Systems	Access System Files Program Manage Data Files Languages System & User Hardware

Figure CL2. User Competence Continuum

considerable problem solving skills.

Some brief comments are in order about the other facets of computer literacy: computer mechanics, computer capabilities, and the social impact of computers (Figure CL3). Some experts argue that everybody needs to know everything about all facets of the computer. The educator must separate the "nice to know" from the "need to know." In thinking about computer mechanics, it is useful to make an analogy to automobile mechanics. A driver does not need to know the intricacies of the internal combustion engine to be a competent driver. However, just as the driver knows that a car is a mechanical device that burns gasoline and moves things from one place to another, it is useful to know that a computer is an electro-mechanical device that processes information. Most drivers have a sense of a car's mechanical vulnerability. They know enough not to put water in the gas tank or shift into reverse when the car is moving forward. Computer users need about the same level of knowledge to successfully use a computer.

With respect to the social impact of computers, there are many educationally relevant issues. Clearly, if the school teaches the skills necessary to access information stored in multi-user systems, the school must also teach the ethics of user responsibility. The automobile analogy holds here also. A license to drive a car implies the knowledge and skill to drive competently and moral responsibility for the vehicle.

	Educational Issues
COMPUTER MECHANICS	Need to know vs. nice to know
User	
Machine Operator	
Maintenance Engineer	
Design Engineer	
COMPUTER CAPABILITIES	
Past	Can the computer solve the nation's educational problems?
Present	
Future	
SOCIAL IMPACT	
Improved Quality of Life	What are the trade offs?
Computer Equity	What is the school's responsibility for maintaining computer equity?
Threat to Privacy	
Responsible Systems Use	Is it the school's responsibility to teach responsible computer use?
Morality-Computer Crime	
Philosophy	Can computers think? Learn?

Figure CL3. Other facets of computer literacy

All citizens should be informed about the tradeoffs between the computer's advantages and disadvantages. There are clear advantages to having a medical history and financial profile available to a doctor treating a patient for the first time or to a banker from whom a loan is sought. However, the benefit has to be weighed against the accompanying loss of privacy.

Understanding computer capabilities requires some sense of what computers can do, how fast they do it, how much it costs, and cost effectiveness. These questions are not as important for students as they are for educational policy makers.

Considerable planning and discussion time must be devoted to issues related to the instructional use of the computer and computer literacy. The preceding section was meant to inform that discussion by specifically providing information about computer literacy and raising educational issues relevant to scientific literacy, which a school district needs to consider in the planning process.

When planning a computer curriculum, the district needs to be aware that most jobs for the high school graduate will require only the lower levels of user competence. Economic projections indicate that there will be relatively few jobs requiring programming skills for high school graduates (Levin Rumberger, 1983). However, in our computer society, everyone must be a confident and willing user of the machine. When parents, business leaders, and the military demand that the public school produce computer literate graduates, they must be prepared to specify what, for their purposes, constitutes computer literacy. Then the district must decide the extent of its responsibility to develop computer literacy in its students.

The Spectre of Time

Managing technical information and defining computer literacy are difficult but doable aspects of the planning process. There are, however, other aspects related in one way or another to time and, ultimately, money, which present more problems, such as: hardware purchase, teacher development, and computer access time.

For most school administrators and board members, planning the district's computer program is synonymous with purchasing the machine. The educational administrator's first question to the computer expert is usually: What machine should my district buy? If nothing else, this paper should convey the message that the question of machine purchase comes late in the planning process, following the important decisions of how the machines will be used.

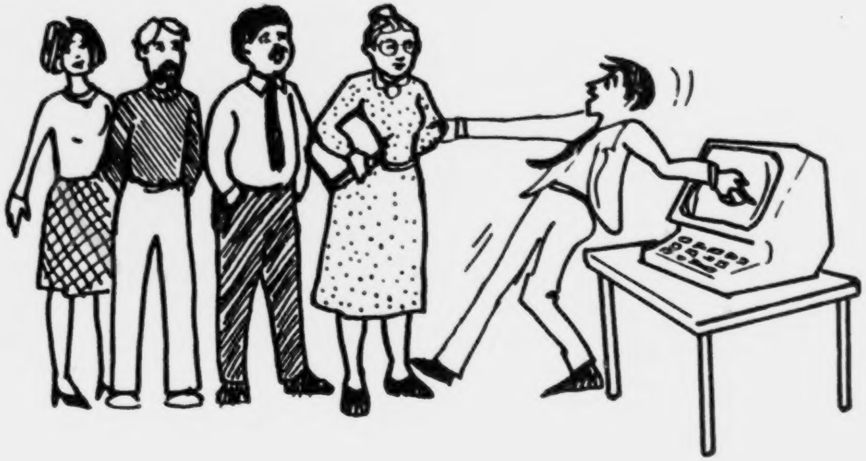
The pressure on schools is to buy now, but common sense suggests that waiting is the more prudent course of action. Computer technology is advancing at a tremendous rate, which means that computers with new capabilities (voice synthesizers, integrated video disc, touch screens, etc.) are becoming available to the education market. It also means that next year the district can purchase a machine with this year's capabilities and computing power at a lower price. A detailed discussion of how thus to incorporate this information into a school plan is beyond the scope of this paper. The facts, however, suggest that reasonable courses of action include some combination of the strategies of (1) limited purchase for a specific long-term use and (2) purchase of equipment that will accommodate new capabilities and can easily be adapted to increase processing capacity. For example, if a district decides to introduce computer programming in the fifth grade, it may be quite reasonable to buy MIT Logo (which runs on Apple II). Recognizing that the Apple IIs will only be used for a single purpose for their lifetime, the district does not have to be concerned that the machines cannot be used for more sophisticated purposes (Figure 6).

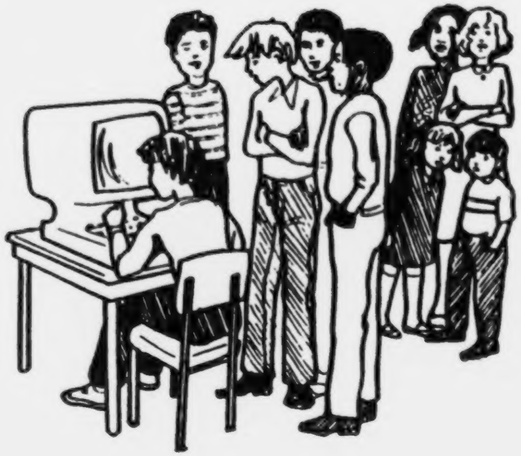
An example of the second strategy is the purchase of a machine with a moderate memory capacity that meets current administrative and instructional operating needs in combination with a feature that allows more memory to be added to meet future needs. Planning with this strategy in mind allows the district to equalize its expenditures, meet its current computer needs, and have a computer system that can be expanded to meet future needs.

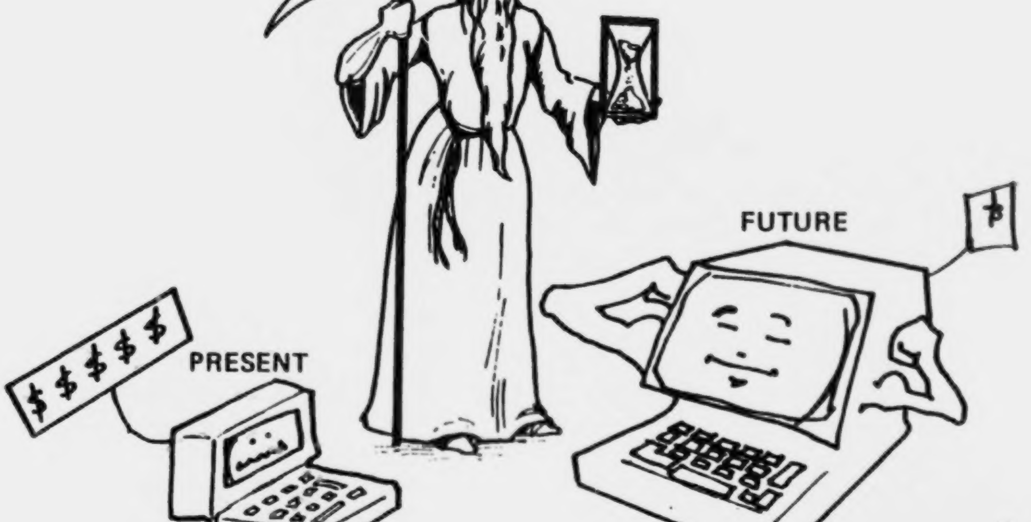
A second time related issue concerns students' access to the computer. Currently, the computer is a scarce resource. Student access to the school's computer is limited. This has both equity and instructional implications. Here are some facts about computers in schools (Becker, 1983). There are more computers in districts that serve upper and middle class families than in those serving the disadvantaged (SEDL, 1981). In the overwhelming number of cases, computers are used to teach programming to academically superior students (Becker, 1983). Boys are much more likely to have access to computers, both at home and at school, than girls (Report on Education Research, 1983). These facts support the concern that a computer elite composed of middle class white males is becoming a reality in American society. School districts need to be aware of the trend and take steps in planning computer use to reverse it.

The instructional issues are the most distressing, given the myth that the computer is the way to achieve educational equality. In reality, there are not enough computers in schools to make any significant impact on student learning. Future prospects look dim. One computer in a classroom of twenty-five students translates into about nine minutes per student per week on the computer (45 min/class x 5 classes/week - 25 students/class). Therefore, the futuristic notion that the computer can contribute significantly to the improvement of learning must be tempered by economic realities, of which time is

Figure 6



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only one. Software quality and machine capacity are other aspects of the economic reality. The available educational software is of generally low quality and does no more than provide electronic drill and practice. There is little software available to schools that does any teaching, or anything else that makes good use of the computer's potential instructional capabilities. With only a few exceptions, the good software that is available can be used only on one computer, thus effectively reducing the availability of good software. The reasons for this state of affairs are largely economic. There is little profit in educational software. As a consequence, most software is developed by computer hackers who know little about curriculum or instruction. Educational games, drill, and practice are about the limit of the hacker's ability to design educational software. The hardware-software capability situation is also an economic one. Hardware manufacturers want to keep software capability limited. The availability of good software is a powerful factor in promoting sales.

There is almost no educational software available that makes use of the computer's unique capabilities to improve instruction. Computer enthusiasts describe the wonderful potential applications of the computer as if these were currently available to schools. Computer instructional systems that claim they can solve the nation's educational problems should be regarded as fantasy. A computer system that acts like an intelligent tutor is still remote. Before the computer can be programmed to be an effective tutor, descriptions of effective teaching must be developed.

Another instructional issue is related to the teaching of computer programming. There should be some healthy skepticism for the assertions that students are developing any significant programming skills in most public schools. Learning to program requires that a student have access to a micro computer or a terminal for a considerable amount of time. Studies indicate that high school students actually receive one hour per week of computer time, which is insufficient for most students to become skilled programmers.

Students need time, and so do their teachers. Staff development for computer use, if done properly, requires considerable time. Many teachers are computer phobes. Typically, the high school physics or calculus computer philes are teachers who are begging for computers. The computer phobes are typically art or humanities types who teach elementary students. Such phobias must be recognized, and dealing with them requires considerably more time than has been traditionally given for introducing teachers to educational innovations. Teachers need: (1) to overcome computer anxiety, (2) to be convinced that computers are useful for instruction, (3) to learn to operate the computer, (4) to become familiar with the instructional materials their students will use, and (5) to manage the computer in the classroom.

The most effective approach, when introducing teachers to the computer, is to appeal to the teachers' most basic instinct -- to effect learning in their students. Teachers want their students to learn, are rewarded when their students learn, and will use an instructional procedure once they are convinced it facilitates learning. Particularly effective is showing the teachers how a computer can teach something that they know they can't teach well. If the students learn, the teachers will be asking for computers for their classrooms. Teachers also need to be given enough time to learn to use the computer, to become familiar with the instruction, and to observe one or two children working through the instruction. Finally, it is important to admit that computers are a colossal classroom management problem that teachers need to tackle. The management problem derives from two facts. First, scheduling children to work on the computer, unless carefully planned, can be a full-time occupation. Secondly, the computer can easily become an attractive classroom nuisance. Techniques to deal with these management problems must be a part of programs designed to introduce teachers to effective instructional uses of the computer.

My own experience with introducing computer instruction into an elementary school has been very positive, but admittedly time consuming, as this brief history will illustrate. About a year and a half ago, one teacher was introduced to a computer-based elementary math program. Currently, the math program is successfully operating in the first, second, and third grade classes in the teacher's school. To start at the beginning, a colleague and I had designed computer-based instruction to teach base-ten numeration. This is a topic central to the elementary arithmetic curriculum. Teachers will readily admit they can not successfully teach this topic. In confidence, many will admit that they don't understand it very well themselves, much less feel confident about how they teach it. An important feature of our success was that the computer was used to teach something the teachers did not feel competent to teach. Our "pioneering" teacher, Mrs. Kaufman, was introduced to the instruction in the context of doing a critique of it. She was shown how to use the computer and was put into a room by herself to work through each lesson and write a critique. When she finished, she sat with one of her problem math students and observed him as he did the lessons. Her task here was to describe any problems the boy had with the computer or the instruction and, through discussions with the boy, determine the effectiveness of the instruction. The teacher's original critique of the instruction was negative. It wasn't done the way she usually did it. However, after observing Jonathan, her assessment changed. Her observation convinced her that the computer did a better job of engaging Jonathan in the learning task, and "slow" Jonathan learned the math with which many of the brighter students in Mrs. Kaufman's class were still struggling.

At this point the teacher told me that she wanted the program for her class. Since we were looking for a field test site, I was delighted, but I felt compelled to specify the extra work involved in order to have the program in her classroom. Mrs. Kaufman was still eager to use the program, so we planned together the introduction of the computer to the third grade and the scheduling of five classes on the computer. The teacher planned the schedule and arranged with the principal and the other third grade teachers to allow children to leave their classes for their computer time. At first the teacher carefully controlled and managed the scheduling. However, the necessity for this disappeared quickly. The computer was so popular among the students that when a child was scheduled to be at the computer, the teachers were confident that that's where the child would be. All the teacher needed to do was to make a weekly master schedule. The children did the rest. The computer was used all day long. If a child didn't get to the computer, another child would take his place. This year, the first and second grade teachers asked to have the program for their students. Mrs. Kaufman helped one teacher in one grade, who was responsible for the program, set up the schedule. The implementation for ten more classes occurred without difficulty. The process, as I have come to conceptualize it, applies the same psychological principle as Tom Sawyer applied when he wanted to get the fence painted. One willing teacher using the computer successfully is a more effective than hours of talking to teachers in in-service programs. In effect, we gave one teacher in-depth training and let her teach her colleagues.

A word now about the computer as an attractive nuisance. The third grade teachers had a grade level meeting to decide where the computer would be located. When the computer arrived at the school, it was placed in a closet. We measured the degree of the computer's acceptance by its location in the classroom. It took from mid-September to January for the computer to be moved out of the closet and into the classroom. The teachers' intuitive sense was that the computer was a play-thing more suited to an arcade than a classroom. When they came to recognize it as a serious educational device, they let it into the classroom. The successful implementation of this program into a school took about fourteen months and entailed employing the pioneer teacher full-time for a summer. Given that no additional in-service training was necessary for the fourteen other teachers involved, this strategy is quite cost effective. Once again, the strategy is consistent with the general principle of prudent action where computers in schools are concerned.

The computer has the potential to improve schools. However, given current economic realities, it is doubtful the potential will be realized. Under current conditions, schools are well advised to: (1) develop a comprehensive plan, (2) let educational priorities guide the formulation of the plan, and (3) be prudent in the purchase of machines. The best course of action is to plan now and buy later (Carnegie).

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THE APPROPRIATE USE OF NEW TECHNOLOGIES IN SCHOOLS

Abstract: The most recent technology to have a major impact on schools is that of microcomputers. They are now used across the curriculum as a teaching aid, but the full potential impact of microcomputers on the school curriculum has yet to be explored. Although much software is currently available, some of it is of dubious quality and may mean that teachers are unwilling to use the new technology. Considerable in-service training is needed.

1. INTRODUCTION

(a) What are the new technologies?

Of the many recent advances in technology, it seems that biotechnology, microelectronics and computers are those that are having an impact on the school curriculum. Recently there has been some discussion about biotechnology in schools, but undoubtedly the fastest-growing technology which currently raises issues in schools is that of microelectronics and computing. Often the words microelectronics, microprocessors and microcomputers are, incorrectly, used interchangeably; perhaps this is because the new technology has such widespread effects. It has been suggested that there is only one new technology -- Information Technology -- which links together the three areas of computing, microelectronics and communications.

The impact of the microchip on society has already been great -- some might say overwhelming -- leading to statements like "the information revolution is the second industrial revolution." It

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is changing patterns of employment and methods of communication, and perhaps it will change approaches to teaching and learning.

(b) The new technologies in schools: a United Kingdom perspective

The introduction of microcomputers into schools is an almost unprecedented example of central government directly affecting the school curriculum -- in the United Kingdom it is rare for central government to direct educational policy. However, the decision to subsidize the purchase by schools of microcomputers (of specified types) has meant the rapid introduction of the hardware into a large proportion of all schools. The only prerequisite was (and still is) that two staff from each school accepting the offer should undergo in-service training. Many local education authorities (LEAs) are matching the government's offer on hardware, to the extent that it is not uncommon for secondary schools to have a network of six to eight work-stations in a computer room and stand-alone machines available in science departments. Because most LEAs have specified the make of microcomputer they will support, all the machines within one school will probably be compatible.

In 1980, central government announced the Microelectronics Education Programme (MEP) to stand alongside the hardware. This now has a budget of 18,000,000 pounds over six years for work covering secondary, primary and special schools. There are fourteen regions across 109 LEAs in England, Wales and Northern

Ireland. Each region has a Regional Information Centre whose role is to disseminate information (including software), run in-service training courses, and sponsor and encourage curriculum development in partnership with LEAs. The work of the MEP centres covers all aspects of the new technology, namely: computer studies, computer aided learning (CAL), electronics, microelectronics and control technology, word processing, communications and information systems.

(c) The pressures created by the new technologies

All the publicity and financing directed at getting computers into schools has meant that many teachers have felt the need to obtain the technology without having the knowledge to use it or to evaluate its use. Pressure from headteachers, parents (and pupils) means that any school, secondary or primary, without a microcomputer is somehow deprived.

Despite all this, computers in most schools are used in an unstructured way by enthusiastic teachers -- indeed, some become so enthusiastic that their colleagues consider them 'computer freaks.' There are teachers who use the hardware without really knowing how to, and there are those who know about the hardware but fail to appreciate its educational use. A balanced use of microcomputers in schools still seems a long way off.

The ASE considered the place of microelectronics in the school curriculum. (1) This statement suggets a whole school policy, with a teacher responsible for coordination of microelectronics across subject boundaries. The belief that students will need a balanced understanding of microelectronics and computer-related activities, practical experience of the equipment and an appreciation of the social and economic effects of the new technology (2) leads to the conclusion that the technology should be incorporated across the curriculum.

2. APPLICATIONS OF THE NEW TECHNOLOGIES IN SCHOOLS

(a) The introduction of microelectronic technology

As with previous technological developments (for example, video, television and radio), schools will need to apply the technology developed for domestic and commercial use. As microelectronics have become an integral part of such equipment as clocks and calculators, they have been used by schools. Already it is cheaper to replace digital stopclocks than repair spring-wound ones. However, this 'hidden' incorporation of technology is not enough.

It is rare to find new technological developments directed purely at education -- but in the microelectronics area this is beginning to happen. Cheap, versatile science apparatus (for example, VELA and GiPSI [3]) for data logging is available. Microcomputer and microprocessor controlled systems are being developed for use in special education to alleviate some of the physical and sensory handicaps of the students. In this area MEP has much development work in progress. Again, some microcomputers have been designed specifically as educational tools; for example, Research Machines Limited designs microcomputers with school and college educational use as its prime function, and the BBC developed hardware for education in the home and school. Hopefully, machines designed for educational use will make their use and inclusion in school work easier and more effective.

(b) The current administrative use of microcomputers

Already, microcomputers are being used as an administrative tool; (4) indeed, some headteachers see this as their prime use. For machines commonly found in UK schools, good, easy to use word-processing packages are available. Of course, these are being used to produce traditional worksheets.

Record keeping lends itself to adaption to a computer-based system. Many individual teachers, as well as whole schools, use such systems. The computer marking of external examination questions is a well established practice. Many teachers are involved in routine assessment and progress monitoring via tests, and this is now possible using a microcomputer (5) as the basis of a Computer-managed Learning System. The microcomputer marks questions diagnostically, routes the pupil to the next worksheet and keeps an up-to-date record of marks for the teacher.

Some commercially available CAL software has hidden record-keeping facilities, but it seems that this potential is under-used by most software packages.

Many schools are using microcomputers for timetabling; (6) again, packages are available for analyzing pupils' actual choices, for analyzing staff and room deployment as well as printing timetables for individual pupils. It is possible to grade texts on one of eight different readability scales (7) or to analyze examination results using commercially available software packages.

Microcomputers are being used to monitor chemical stocks (8) and as a user guide to science apparatus. The efficiency of such uses must depend on the stock control system itself and the accessibility of a microcomputer.

(c) Microcomputers as a learning aid

Computers were originally equated to teaching machines and used for 'drill and practice' learning. Unfortunately, some teachers still believe this ought to be a major use of microcomputers, despite other developments.

Much emphasis has been placed on the interactive tutorial use of computers, e.g., CALCHEM (9), and although this type of CAL is now available on microcomputers, even this does not necessarily make full use of the technology. The graphics capabilities of the microcomputer make it an ideal electronic blackboard, and much software of this type has been written for schools. Although intended for demonstration, such software can be used by individual students, or small groups, with the right support materials.

Already there are games to motivate pupils. For example, poetry or prose can be developed in an interactive way by a group of students. They face a blank screen; only punctuation is displayed, and they are expected to work out the text -- a scoring system penalizes guessing and rewards correct answers. Real cooperative learning takes place; pupils discuss and debate alternatives, thinking carefully about possibilities and eventually even deciphering the scoring system, so they can 'beat' the machine. Pupils of all levels of ability take part in, and benefit from, this change in learning method.

Simulations and decision-making studies are an obvious use of microcomputers. Pupils can simulate the control of oil pollution. Alternative methods of controlling environmental damage are offered to the students, who need to assess economic and environmental factors before selecting a suitable method. The consequences of their decisions can be explored in a realistic way -- the wind direction changes, and even time is precious.

Data interrogation as a method of learning is used by social science teachers. Census data for over a hundred years for a particular parish is available. By reasoned interrogation of this data base, it is possible to follow population changes and assess the impact of events like a plague or a war.

As with all CAL techniques, the effectiveness of the material depends on the way it is used and supported by teachers. Software packages cannot replace a good teacher.

3. THE NEW TECHNOLOGIES AND SCHOOL SCIENCE: A CURRENT SURVEY

(a) Microelectronics

Science as a school subject is especially well placed to utilize microelectronics; not only can science use the new technology as a teaching and learning aid, but the technology itself needs to be part of the science curriculum.

The current science curriculum contains little, if any, electronics; hopefully, future developments will alter this situation. Although many individual teachers have been quick to develop materials, the examination boards have been slow to react.

(b) Microcomputers as a laboratory aid

The availability of microcomputers in schools means that it is becoming possible to have one permanently in each laboratory, connected through interfaces to monitor experimental data. Programmable instructions of varying sophistication are also available for collecting and displaying data. Indeed, it would be more economical to use one programmable instrument than several single function meters. (10) Apart from the educational advantage of enabling students to see microelectronics in action, these devices can collect readings over a much longer (or shorter) time scale than normal laboratory conditions permit. This extends the potential experimental work available to students; no longer is work, or its accuracy, governed by the limitations of a stopclock. Students could become real experimenters rather than repeaters of investigations. The kinetics of both very fast and slow chemical experiments can be investigated, and biological data can be logged over months.

Having collected the data, the microcomputer can be used to process it. The use of a program such as STATPACK (14) enables students to investigate quickly the mathematical relationships between sets of data and perhaps establish a 'law' empirically rather than following instructions to plot x against y.

It is possible to use actual experimental data as a basis for simulation; for example, students could perform a kinetics investigation and use their results to predict what might happen at temperatures (or pressures) normally unobtainable in school laboratories.

One area of use for a microcomputer in a school laboratory which is being explored is that to control experiments by monitoring the progress (11) of the reaction. As an educational tool, this will need more investigation.

(c) CAL in Science

Simulation of experiments not normally possible in school laboratories is one major use of CAL in science. Many programs written under the Chelsea College 'Computers in the Curriculum' project (12) are simulations. Students can investigate the effects of pollutants, or fishing, on pond life; or the effect of temperature and pressure on NH3 production; or the cost of heating an under-insulated house. Simulations can be extended to incorporate educational aims from the affective domain into science teaching. For example, the simulated study of the industrial production of H2SO4 enables students to determine the optimum value of the temperature, pressure and reactant ratio by chemical criteria; then the effect of the application of economic criteria on these values can be investigated. Further criteria (such as pollution control) can be applied, thus showing that the conditions used by industry are actually far from chemically ideal. Perhaps this is a further example of the teaching of science, society and technology using the technology itself! The investigation of models of actual industrial process reflects some of the processes of science, perhaps increasing the pupils' understanding of what science is about, and giving an appreciation of the value (and limitations) of models.

4. FUTURE POSSIBLE DEVELOPMENTS

(a) In Microelectronics

"Education through Science" (13) gives as one broad aim for science education "the attainment of a basic understanding of the advanced technological societies, the interaction between science and society and the contribution science makes to our cultural heritage." The microchip is surely one area where these implications might be tackled, but how? One idea suggested in Rethinking Science, (14) a collection of papers on teaching science in its social context, is the use of data interrogation. Should we not use the technology itself to teach about technology?

In the United Kingdom, there is currently much discussion about "Science for All" -- but what sort of science for all? The ASE document "Alternatives for Science Education" (15) suggested science in the world of work, among its six contexts for science education. The impact of microelectronics on the world of work means that all pupils should have some relevant experience. If this is to happen, then changes in the school curriculum are necessary. "Microelectronics literacy," as it has been dubbed, should be part of the core studied by all pupils -- whether in science or not.

While microelectronics literacy is for all students -- as is CAL -- learning about electronics and microelectronics is not necessarily so. The inclusion of appropriate microelectronics devices in science will gradually occur, but where, if at all, should microelectronics occur in the curriculum?

In the United Kingdom, the current system of option choice at 13+ means that some pupils study no science after that and many students no physics. Most physics syllabi include very little electronics and even less microelectronics. Thus, most students will leave school at 16+ with no experience of electronics. How much of the basic science involved can and should be taught? Very little guidance is available to teachers although the merits of two approaches, the 'systems' approach or the 'components' approach, have been discussed. (1) The components approach considers how the components work and explains how circuits work; the systems approach explains how logic gates work and how components may be put together to produce the desired effect. The inclusion of specific topics, such as methods of switching and control and the construction of devices using microelectronics, has been suggested. (1) Perhaps this is one area of the curriculum where links between science and craft, design and technology departments, should be developed to ensure that all pupils have some experience of the new technology.

Although much has been said about interdisciplinary links, and some schools have taken positive steps to encourage this by using the faculty system, little real progress has been made. Perhaps this is not unexpected, as traditional teacher training (at secondary level) is subject specific and hence many teachers are unhappy about teaching outside their subjects. Indeed, some teachers are almost hostile to the idea of interdepartmental links; they see no need for such developments and offer reasoned arguments for the status quo. If education through science is to be achieved, then there is a major task that has yet to be tackled: how can teacher attitudes be changed?

As new technological knowledge and experience is included in the school curriculum, other science subjects -- for example, geology and even chemistry -- will be under pressure. If, as the ASE policy statement suggests (13), the science curriculum should incorporate a reasonable balance between specialist and generalist aspects of science, then it becomes crucial that schools develop an approach to the study of science, which means that scientific aims and processes are experienced across the curriculum. This has major implications for in-service training.

(b) Future developments of CBL

The Schools Council "Computers in the Curriculum" project suggests that there is currently a need for two different classes of software: that to meet the immediate needs of the schools and the content of the current science curriculum and that to meet the changing needs of society -- which may mean software on material currently outside the existing science syllabi. This second class is one example of how microcomputers could indirectly alter the school curriculum.

If good software is available, there is the potential of introducing science -- its processes and perhaps contents -- across the school curriculum. Already home economics teachers are using data interrogation to teach the principles of a good diet -- encouraging pupils to formulate and ask questions like "what if . . . .?" Science teachers need to be aware of these developments and to capitalize on them.

One use of the microcomputer that has proved very successful as a teaching aid is to use the enthusiasm of the student for writing software. When asked to write a program to simulate first order kinetics, the program designer needs to know the background of the problem. Writing a program on the topic can teach the scientific principles behind it. Certainly teachers comment that they have learned more chemistry by trying to design and write a program on the topic!

(c) Microcomputers and communications

Although microcomputers can now be used by householders (on line to a mainframe computer) to pay bills, book holidays and order shopping, little progress seems to have been made in this use of the technology in schools.

The distribution of software is a good example of this. Only one LEA distributes software in its library to schools and colleges by a telephone link between micro and mainframe computers. Software can be downloaded quickly, the limit of efficiency being the telephone link! The use of British Telecom's Prestel service ought to make software available on a national basis, but the system has many limitations.

It was intended that the MEP regional offices should be linked by similar communications technology, but there appears to be little real progress. It is intended to announce the inauguration of a national educational data base in the near future. It remains to be seen what effects this will have.

Hopefully the outcomes will be more positive than one example from my own LEA. It was possible to link micro and mainframe computers, as above, for software downloading. It was hoped the system could be used for rapid inter-site communication -- but the cost of replacing a dying mainframe stopped this system!

5. POTENTIAL CHANGES IN LEARNING STRATEGIES

Microcomputers are being used in conjunction with other examples of communications technology as tools for distance learning. The BBC has published a series of audiotapes and accompanying software for use when teaching about computers and microelectronics to 11-13 year olds. More sophisticated examples include CYCLOPS, an audio-visual system using TV, audiocassette and microcomputer developed by the Open University as part of their distance learning methods, and EDUTEXT, a video cassette system with accompanying software developed by the National Physical Laboratory. Both of these systems could be used in schools as individual or small group study aids.

Not only can the microcomputer enhance traditional teaching methods, but it could alter teaching and learning styles. Computer managed learning has been briefly discussed. The potential of the micro in CAL is in helping the teacher to become an effective manager of the student's learning. CML can relieve the teacher of the burden of low level management tasks; it can allow the experience of the teacher to be deployed in support of all students, and it makes the use of independent learning strategies feasible with large numbers of students, thus enabling the teacher to spend more time as a tutor to individual students. The use of independent learning methods has currently met opposition from traditional teachers who see their role as a 'giver of information.' It is now expected that most people will need to change jobs and undergo retraining at least once in their lives. If school education is to equip students to live in a changing society, surely they must be encouraged to be more active managers of their own learning. Study skills ought to be part of the school curriculum.

As knowledge of science and manual skills become less useful in life, their legitimacy in school education will become less apparent to students, and motivating learners will become harder.

The use of data interrogation as a teaching or learning aid needs to be explored more fully. In this age of information explosion, students need to be able to formulate the right questions and interpret the results to such questions in an intelligent way. As the use of publicly accessible data bases, such as Prestel or Ceefax, becomes more widespread, it will become more important to develop students' thinking processes, encouraging them to analyze information. The school library is a logical place for information technology in practice. Just as currently students use encyclopedias for project work, they ought to use computer data-bases.

It was Samuel Johnson in 1759 who said: "Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it." Perhaps school education has concentrated on the first to the detriment of the second kind.

In Mindstorms (17), Papert envisages a reversal of the current approach to computer aided instruction in which he claims computers program children. Using LOGO, Papert can create an alternative learning environment in which children program computers to understand the concepts of mathematics. He suggests that learning to communicate with computers can be a natural process and that it may actually change the way learning takes place. This prospect is only briefly mentioned here. Many teachers have never read Papert, and most would see his ideas as unrealistic. What is certain is that it is essential that we investigate how children can interact with computers and use the knowledge so gained to improve our school education.

6. CONCLUSION

All potential changes in teaching and learning methods have implicit and explicit requirements for in-service training. Already there are teachers who believe the technology will never catch on! Teachers need to be trained to use the microcomputer and its software in valid educational ways. Good software has teachers' notes (and often pupils' notes), but even so -- like most technology -- it can be misused.

(How do you misuse a 16mm film? I once knew a teacher who would show films backwards to entertain a difficult class!)

Indeed, programs that at first sight appear trivial may become a valuable teaching aid in the hands of a good teacher. If teachers are to use software effectively, they must become evaluators of software. They must be helped to incorporate it into their lessons and assess the impact of its use, and design software they identify as needed. Currently much software of dubious value is advertised -- teachers need help and guidance on assessing it and the ability to recognize scientific and educational mistakes that can be found in hastily conceived and written material.

Dangers are inherent in the use of new technology.

Indiscriminate use of the computer may lead to teachers losing credibility. Sparkes (18) talks of the dangers of misusing microcomputers in laboratories -- the black box hiding the science, the correct result being displayed by incorrect software. Much of the currently available software under-uses the machine capabilities, and while in theory micros can motivate pupils, they could just as easily turn them off! Much of the software is poorly designed in terms of screen layout and color usage. A whole industry exists around visual media, and some of the experience from this must be transferred to software display. It took many years for educators to become aware of issues like readability when using text books; similar issues will develop from software use. The whole area of interaction between student and machine remains relatively unresearched.

Perhaps more dangerous is the ease with which teachers may reject the hardware. Hoyle (19) talks of the history of education littered with the corpses of abandoned innovations. Learning to use the new technology is difficult and time-consuming. Non-standard hardware (even from one supplier) means that unexpected problems occur in its use, so that although there is a readiness among teachers to adopt computers as a means of enhancing their educational techniques, the ability to do so is lacking.

The training of teachers in the use of computers will be a major task. Not only must they have confidence to operate the equipment and cope with systems breakdowns, but they must be encouraged to use software appropriately. What is appropriate has possibly yet to be assessed; we are all novices in the art and science of microcomputers in schools. All stages of development must be monitored and evaluated. It has been said that the computer is the means to a revolution in teaching and learning (19); for 'revolution,' substitute 'evolution.'

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Discussion: The Appropriate Use of High Technology in the Classroom

Plenary
Jon L. Harkness, Rapporteur

A question was raised about how to measure the quality of computer software. Sigda responded that NSTA reviews software. Clarification was made that NSTA only provides reviews and does not recommend specific items of software.

The suggestion was made that laboratory interface devices may isolate students from desirable concrete experiences in measurement. Counterpoint was offered that classical measurement devices have the same limitation; the thermometer is not temperature any more than is the computer-linked temperature probe.

Comment was made that in CAI systems more could be done to store student responses to provide data on how students learn. More CMI systems also are needed to monitor student progress.

A comment was made that teachers need to be placed in the position of selecting from a great variety of options the best use of computers for science instruction.

The question was raised, "what are the implications of computer-based corporations entering computer-based educational programs into the market place?" Champagne offered an analogy to treatment of commercial textbooks by education as a probable response.

The question was raised, "In addition to using computers for teaching, what should we teach about them?" Effectiveness as a user involving spreadsheets and database software was recommended.

It was observed that while some systems exist in both the U.S.A. and U.K. for evaluation and dissemination of software, but profusion leads to lack of standards.

Teachers need time to interact with computers; often, children have more access to computers than do teachers, and students should be allowed to pursue their own questions using computers rather than lower levels of use such as drill and practice.

There is some danger that students may assume that ultimate truth resides in computers.

B. No discussion followed reports of the four small group rapporteurs in plenary session.

Group I
Jean Price, Rapporteur

High Technology in School

(2) When talking about computer literacy, we should consider the following points:

1. What do we want from education? If one's answer is: "to prepare pupils for life in the outside world," then we must look at the uses of computers in the outside world, i.e, as a utility and as a tool to collect, display and use data.

2. One way to increase computer literacy is to consider a problem that is best solved with the aid of a computer -- then we have to learn to use a computer.

3. Part of computer literacy is realizing what a computer can do. If garbage is put in, then garbage comes out.

4. Information about computer use in the education system beyond the boundaries of science should be available to all. Material becomes obsolete very quickly -- we should be aware of what is currently available. How is this to be provided and by whom?

Good things about computers

A. Computers can be kept up to date more easily than textbooks.

B. Computers can free teachers from record keeping, stock control and other administrative duties -- this permits more time with pupils.

C. Individualized learning becomes possible for pupils with special needs. Voice simulators can be used with physically handicapped pupils.

Worries or bad things about computers

Teachers cannot be replaced by computers. Therefore, science cannot be replaced by computers. We must decide whether laboratory simulations using computers are better than no science at all.

(3) Are we being pressured into using a computer?

List of High Technology

Video disc -- used for training
Satellites for communication
Computers

Uses of computers in schools:

1. Drill and practice learning in science lessons
2. Simulations in conjunction with reality
3. Industrial simulations linked with decision making
4. Laboratory interfacing, to collect, log and display
5. Modelling simulations
6. Construction and use of data bases
7. Finding out how children learn
8. Administration

Areas of possible research

1. Is it reasonable to assume that having a personal compute at home advantages a pupil? Should a national policy be that schools have a computer to overcome disadvantages caused by lack of a home computer?

2. Pupils are often more "computerate" than teachers. Is this a threat? What are the social/educational implications of this?

3. What will be the reception given by the teacher to something which turns upside down the usual teaching process?

4. What degree of professional support is necessary for teachers who introduce computers into the classroom.

Group II
Gary Appel, Rapporteur

The utilization of high-technology in the classroom presents a serious problem of a fair allocation of resources, particularly to schools in poorer communities. How do we assure equal access to the new learning aid by all?

What is computer literacy? Are schools responsible, especially elementary schools, for imparting this? The feeling was that basic literacy was being obtained already in places other than the classroom.

Who can benefit most from the use of computers in the classroom? It was thought that remedial students demonstrated great progress in using computer assisted programs. The computer is very patient. Students receive positive reinforcement and meet with success in their use of computers. It was also thought that computers could best serve a teacher's management needs.

Recommendation:

1. Computer education needs to be part of all teacher education

programs.

2. Teachers should have access to instruction in programming through their district if they so choose.

3. A good system for evaluating educational software needs to be devised and implemented.

Group III
Geoff Oliver, Rapporteur

1) We made an attempt to extend the high technologies we might find in schools from the microcomputer base into the use of risk-benefit analyses, laser discs, navigation techniques, laser pencils, etc.

This led to the realization that the problem of understanding -- even in general terms -- the workings of artifacts and technology instantly become based in a specific time and that without great care, the processes involved will lead to an abstract, conceptual treatment of the topic.

2) An obvious hierarchical order can easily be perceived in which the earth's resources of materials and energy, and the living things with man, must interrelate for two basic components. The control systems and the machines spring from this base, and indeed the systems approach to these diverse and changing technologies might well be a most valuable mode of study.

3) The uses of the microcomputer were perceived as a set of confused and cloudy images -- we were none of us sufficiently well informed to look deep into the future -- computers in the classroom could be used:

to familiarize the user in their operation;
for rote drills;
as a word processor;
as a simulator;
as a control system;
as a device for producing new science;
as a generator of new learning processes with a cooperative interaction between pupil and machine as the computer analyzed the pupils responses and itself responded by posing new questions and problems or giving new insights.

There was a dream of a new data base system that would give information on how an artifact works and guide the learner to lecture and to understand in terms of the basic framework of knowledge and concepts with which he was conversant.

4) Children are a valuable resource -- nowhere is this more true

than in the use of the computer -- the computer too appears to offer opportunities for developing interesting group work and cooperative learning ventures. It may be that boys are inherently more stimulated by computers than are girls -- but this could be due to problems of access, perception of roles, and the nature of the games. Research is required to provide information for both these issues.

5) Research is needed to help resolve the following questions: How can one stimulate the pupil-computer interaction? What are valuable methods for using one computer with large classes? What should be the balance of graphics/instruction/abstract/concrete levels/real world/ideal world examples?

As well as developing programs and simulation exercises, R and D is needed to assess and evaluate existing programs to help us to move forward and extend the futures of knowledge and effectiveness. R and D is needed on programs for group use, individual use, use as a tool, and to develop real learning/teaching techniques.

6. Industrial and military users are making rapid and vast studies in the use of computers. Education is being left behind. Does education need a similar "think tank" and input of funds and resources? Should we look for a partnership between teachers, administration and the outside world to generate these funds and expertise?

Group IV
Art Farmer, Rapporteur

*Yes -- Computers can replace teachers.

Software is not up to the task now, but it is rapidly improving.

See the accomplishments of WICAT in Provo, Utah where a corporation runs a tuition free private school to evaluate its software.

The pressure to purchase in the U.K. takes the form of 50/50 (government grants with inservice training). However, the computer to purchase is the ACORN with limited software.

*Research is needed into the effective use of the computer in the classroom and the interactive relationship between teachers, students, and the computer.

*There is teacher demand for computers and software. There are 700 computers in the Boulder, Colorado school system. There should be a needs assessment.

*Teachers should be trained before purchase. Master teachers should be trained.

*Homes will have computers because word processor units will replace typewriters. Computers also can serve as Babysitters. Parents also feel that students will fall behind if they do not have home computers.

*How does a teacher keep up with software?

1. Read Reviews: Epigram, Micrograms, California User Groups.
2. When you receive software, you must catalogue instantly for others.
3. Should NSTA and ASE publish Reviews? YES
4. ASE should insist on Apple compatible hardware/software for ACORN.

*Teachers should insist on a thirty day period of review for any purchased software. During that time the software can be returned. NSTA and ASE should publish this policy recommendation.

*When purchasing hardware, the evaluation should be based on software, reliability, training time and service.

*When a significant number of machines have been purchased, the district should consider their own central service area. There should be back-up machines available.

*To keep up with modern languages, the machines should have at least 128K.

*Jim Robinson recommends the trip to WICAT to see what is coming.

*Science Texts will all have disketts within five years.

*Teachers should have a Computer Literacy Course (32 hours) to hold them for five years. After that, the new languages will be easy.

*Current Boulder, Colorado science departments use computers as follows:

	Hrs/work
Biology	0
Life science	1
Chemistry	10% of time
Physics	0

PART III

MEETING THE NEEDS OF A DIVERSITY OF LEARNERS

Papers by:

Peter M. Durrant
Alejandro Jose' Gallard Martinez

Discussion

Peter M. Durrant
Head of Biology
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THE NEED TO ADDRESS A DIVERSITY OF LEARNERS

Aims of Education

One of the broad declarations of educational intent from the Plowden Report (1) reads:

> "One obvious purpose is to fit children for the society into which they grow up...for the adults they will become will need to be, above all, adaptable and capable of adjusting to their changing environment."

The DES report (2) lists six educational aims for schools:

1. Help pupils develop lively enquiring minds with the ability to question and argue rationally and apply themselves to tasks and physical skills.

2. Help to acquire knowledge and skills relevant to adult life and employment in a fast changing world.

3. Help students in the use of language and number.

4. Instill religious and moral values.

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5. Help pupils understand the world in which they live, the interdependence of individuals, groups and nations.

6. Help pupils appreciate human achievement and aspirations.

A general educational purpose is to help people to change (3) so that they will develop along different lines from the way they might have done; to alter the way they think or feel, and to actually enlarge their capabilities and dispositions for their own, and society's, good. As educators we want them to improve in everything, to become more skillful, knowledgeable, confident, independent, emphatic, rational and respectful.

Where does science fit into this scheme? To what extent are scientific aims educational aims? A series of scientific objectives are laid out in an ASE consultative document (4) but, condensed into a single sentence, a summary of these could be: "To develop a respect for and an understanding of the natural world within the body of current scientific knowledge." (5)

Although such aims are, of necessity, diffuse and imprecise, they are a statement of general intent -- a focusing attitude onto which discussion can be hinged.

From such an aim, scientific objectives can be established. The ability to recall, comprehend and recognize the validity of facts, terminology, concepts and principles could be a base for these objectives. From this body of knowledge, we want the pupil to seek out and define problems and then to search for a subsequent approach or approaches to solve these problems. The sources of data need to be identified and irrelevancies eliminated. Experiments can then be designed to develop the data in order to distinguish fact from opinion. This data then needs critical analysis to evaluate the information with respect to the original problem.

Further problems arising from the investigation can then be listed. The next phase is to look carefully at the data and to withhold statements if doubts emerge regarding their sufficiency. The pupil should develop an awareness of the social and environmental implications of the problem and its relevance in our modern society.

Such objectives will relate as much to the pupil's personality as to his or her intellectual faculties. Richards states that "science lessons not only develop scientific skills but also social, moral and aesthetic thinking." (6)

Aims and objectives in science must be sufficiently wide-reaching to embrace the various categories of pupils to which they will have to apply. Three groups include:

(a) Those who will become professional scientists;

(b) Those who begin such a course but do not complete it, using it later as a base for an alternative career;

(c) Those who will not formally study science beyond their school years.

The majority of school science courses lays particular stress on (a) and (b) rather than on (c), yet this latter group comprises the majority of our school population.

In a democratic society, everyone should be involved in making reasoned decisions on social issues. In our modern world, where so many things are technology or science-based, a knowledge of science is of obvious value -- almost a necessity in fact. (7) A Biology student should be conversant with his own body's functions and malfunctions. In this way he can understand and make mature judgments about political debates revolving around Health Service cuts or nuclear or industrial disasters. His knowledge of biological interaction will also enable him to make informed statements during resource and conservation conflicts.

Early secondary school science, especially if it is resource or discovery based, will give the pupils opportunities to carry out experiments and to study problems so that they will acquire skills that are not only relevant to science but that will also be useful in everyday life.

It can be seen from the following list of basic science skills that the majority, once acquired, would be useful attributes in later life:

(a) to read and follow simple instructions;

(b) to follow a simple written argument;

(c) to respond to a question with a precise written or oral reply;

(d) to interpret a diagram;

(e) to make notes from a book in their own words;

(f) to use a library to find relevant information;

(g) to use the index of a book;

(h) to operate simple audio-visual equipment. (8)

Science and Other Curriculum Areas

However, there will be individuals who are unable to carry out written instructions, perhaps because of their language inabilities.

Language content is an integral part of any science course; it cannot be left to the English teacher. An implicit component of scientific skills is an ability to communicate in the form of a written or verbal report on an experiment or some scientific phenomenon.

If science is to go beyond a first phase level of watching films, copying diagrams or carrying out simple one-stage experiments, a sound basic knowledge of language is needed. Without becoming language experts, science teachers can and must help pupils understand science by developing their confidence and skills in reading, writing, and talking. A quote from the Bullock Report reveals this line of thinking. "Teachers must know, however, the reading and linguistic demands of their subject and be conversant with the ways in which pupils can be helped to meet them." (9)

Science has, to some extent, an inherent problem. Its insistence on specific terms, which can be quite central to some lessons, may be a barrier to some pupils. The pupils' idea of the meaning of a particular word may not be identical to that of the teacher. Stenhouse states that: "... because thought has no counterpart in words, the transition of thought to words leads through meaning."

'Dissolve,' 'diffuse,' 'amalgam,' 'respire' and 'energy' are words commonly used by both laymen and scientists, but their meanings may differ widely, depending on the user. Scientists may even disagree among themselves over their interpretations. For the pupil to be able to read a text book or understand and answer an examination question, these specialized terms must be mastered.

Another problem often exists in the ordinary, everyday language used by teachers. Such words as 'linear,' 'expert,' 'inverse,' 'error' and 'displace' may be unknown to the average twelve-year-old. Richards (6) shows a correlation between understanding the words and developing an accurate knowledge of the concepts.

Other terms, non-scientific in themselves but necessary for instruction, have an inbuilt ambiguous quality about them and may create a need for clarification for a pupil. How many times has a teacher asked students to learn a topic until they "really know it" when what he actually wants is a detailed description from the pupils? Other statements, such as "become acquainted with," "obtain a working knowledge of" or "realize the significance of" will similarly require explanations.

Mathematical expertise may also be a forerunner of scientific development. Many individuals who are inept at mathematics will be unable to advance in science. A working knowledge of the following mathematical principles and techniques are important for the understanding of biological systems, even to CSE standard: length, surface area, volume, decimals, fractions, percentages, ratios, means, graphs, barcharts and histograms.

Interdepartmental discussions, especially between Science, Math and Technology, as well as -- to a lesser extent -- English, Home Economics and Geography departments, will be of great value in identifying and eliminating some of these teaching difficulties experienced in science.

Aims of Science Education

Our aim must be to stretch towards both ends of the learning spectrum and to introduce pupils to the essentials of scientific mental activity (classifying, interpreting, hypothesizing, predicting, observing and so on). Carre concludes: "The pure character of science is not knowledge itself but the nature of that knowledge, its tentative conclusions and procedures used for generating them." (11)

Scientific objectives are educational objectives. The importance of their role and inclusion in the curriculum order is as paramount as that of English and Mathematics. The success or failure of these objectives will depend on the way that the world of science presents itself to its populace. The science teacher must be an educated scientist, so that he can remove the self-imposed blinkers that school-age pupils often seem to wear!

If we believe that science has a fundamental base in education, then the methods that implement the teaching of science in our schools should follow the same philosophies.

Streaming

Streaming of and within English schools was not established until the late 1920s. In 1937 an HMSO publication, "Handbook of Suggestions for Teachers," believed streaming to be a highly desirable practice. With the close mixing of and cooperation between the social and academic classes during the Second World War, people's attitudes to the principle of equality sharpened. Reports through the 1950s suggested various educational reforms, but it was not until the advent of consistent Comprehensive School arrangements in the 1960s and 1970s that, of necessity, new patterns for dealing with children occurred. (12) (13) (14) Instead of being streamed, pupils were:

(a) banded: a broad division of a year group into two, three or four bands, depending on school size. As in streams, the curriculum of each band could differ;

(b) blocked: a number of classes were jointly timetabled for subjects, allowing pupil and teacher rearrangements;

(c) setted: whole year groups or sections of year groups were timetabled simultaneously and then subdivided into sets on the basis of attainment. If little movement occurs between the sets, this could be classed as a micro-variant of streaming.

(d) mixed ability: no academic distinction was made between children. They were arranged:

(i) randomly (12) or on a basis other than ability (e.g. neighborhood). This procedure was called non-streaming,

(ii) with each class having a similar ability range, called unstreaming.

Few schools showed mixed ability grouping in its purest form, in every subject and in every year group. Yet comprehensive education is an irrelevance if its implementation is not based, at least in part, on mixed ability. A streamed or banded comprehensive school is little different from the old selective system of Grammar, Technical and Secondary Modern School, apart from the geographical fact that all the alternatives are housed on the same site.

Her Majesty's Inspectors (15) laid stress on social development as a main argument for mixed ability. They claimed that mixed ability teaching, as well as creating a sense of belonging to a non-segregated community with equal opportunities for all pupils, prevents the creation of a delinquent subculture.

(16) This 'sink' group may be, however, more a reflection of school values, and a change in attitude may be necessary rather than a change in organization. (15)

On educational grounds the sheer wastage of talent, with all its implications for the individual and society, is a good enough reason for implementing mixed ability. Jackson (17) indicates that streaming may have played a major role in this process of waste.

Kelly records: "Education should be designed to offer everyone something of value defined in terms of his own individual requirements." (18)

Can such an aim as this only be achieved in a non-selective environment? Evidence suggests that through mixed ability teaching a levelling of attainment occurs, with the slower pupils improving their performance. (17) (19) It does seem that, far from catering to differences in ability, streaming may create differences. The rejection implied in a 'lower' group cannot but result in disaffection among pupils, teachers and parents.

If a generalization is possible, surveys which have attempted to compare streamed and non-streamed systems indicate that there is no evidence to suggest that non-streamed pupils do less well than the streamed individuals. (20) (21)

Why do many schools retain, at least in part, some form of streaming? The doubts stem mainly from consideration of Plato's "Children of Gold," that is, underachievement of the high fliers, the problem of coping with the exceptional child. Boredom, lack of motivation and disruption in the 'peer' group are the symptoms that cause the doubts. However, in a well-constructed scheme, the brighter pupil would have a chance to develop at a faster rate than in a streamed group where teaching would be aimed and held at the average level of the class.

Another question needs to be asked. Can science be taught in mixed ability groups? Science is very much an evolutionary subject. A base of knowledge and technique must be established before the student can progress to another stage. As in Mathematics and Languages, C and D cannot be developed until the pupil is fully conversant with A and B. The base of science is a broad one and can embrace a multitude of pupils.

Many secondary schools in England and Wales have mixed ability science for years one and two, teaching general or integrated science for these first two years. This practice has made possible a skills or technique approach to science, diverging from the fact-accumulation system so prevalent when the subjects were taught separately. In the third year, science is often split into Biology, Chemistry, and Physics as a prelude to selection of fourth and fifth year subjects. These separate subjects can then be taken along with a General Science-type subject to various levels: CSE, O-level, TEC, with a multivarious collection of syllabi and examination boards. At the third year stage science groups may become settled, and almost certainly this is the case by the fourth year although there are instances of mixed ability successes into the O-level years. (12) Pupils with different abilities and levels of understanding tend to select different courses suitable to their individual interests. The pupils almost set themselves, although teacher and parental influence may alter a situation, sometimes quite correctly, where the child may be too young, immature, or ill-informed to be able to make a reasoned judgment of this nature.

If unstreaming and non-streaming are to have a chance, then the methods of implementation must be right. The 'chalk and talk' system has doubtful viability, although brighter pupils may be more comfortable with a teacher-centered lesson.

Streaming and Teaching Methods

A comparison between approaches to the streamed and unstreamed lesson necessarily involves a comparison between exposition, the predigested teaching technique, and discovery, a process of finding out for themselves. There is no reason why in a streamed situation the latter should not be employed and encouraged. The point is, however, that in a mixed ability situation it is virtually impossible to use the former without considerable problems ensuing. Samuel Smiles said: "We often discover what will do by finding out what will not do, and probably he who never made a mistake never made a discovery."

An old Chinese proverb has a similar message:

> "I hear and I forget,
> I see and I remember,
> I do and I understand."

The discovery approach does take much longer, but the overall depth of scientific understanding gained by such pupils appears to be considerable. (22) A greater number of girls seem to choose the physical sciences when care is taken to teach the skills of science and to increase their confidence by allowing them to carry out investigative experiments -- a statement of some relevance when it is considered with 17% of girls take no science in their fourth and fifth years compared with a 9% figure for boys. (23)

We must inject here a note of caution into our enthusiasm. What will appeal to some pupils will be unacceptable to others. Not every pupil will be capable of tolerating the ambiguity and uncertainty of open-ended enquiry. Not all pupils can and will work to their fullest extent on their own. Should the pupil then be expected to adjust to his course or vice versa?

Kelly (18) suggests class teaching should be rejected outright, but surely this must be tempered with some realism.

The idea of teacher-centred initial discussion, emphasis on safety precautions, the demonstration of a specific technique or the terminal appraisal must still hold a place in most of our science lessons.

Exposition is a comparatively easy teaching option when compared to discovery. Unstreamed discovery-based teaching involves the coordination and organization of many factors. ASE booklets (13) (14) form an excellent reading base for any teacher embarking on this course.

The general attitude of teachers to this way of teaching must be a positive one. Teachers must be committed to the scheme; even an unwilling minority would be a significant stumbling block to successful implementation. Here the headteachers can have a dominating influence in the appointment of staff. Also the training of teachers in college and universities can affect the success of the approach, as can the in-service facilities that exist for practicing teachers. Mixed ability teaching makes great demands on professional skills in terms of organization, presentation and implementation, whereas in a streamed class these aspects may be neglected or carried out less efficiently.

The school, through its local authority, must also provide special facilities. Laboratory accommodation, timetable flexibility and abundant resources are required. Adequate ancillary staff to service apparatus, a strong link with the library to supplement departmental research facilities and the establishment of a resource centre are additional considerations.

With the decrease in the central role of the teacher, there is a need for packages, visual and written, which are expensive and time-consuming to produce.

A major tool is the workcard sheet or taskcard. This has developed from a pre-1960s obscurity to perhaps an over-dominant position in our modern classes. With the wider ability spread in non-streamed or unstreamed groups, a diversity of language development is always present. A policy of the school may be to remove those pupils with special language problems to remedial reading lessons or, better still, remedial staff may come into the lesson and sit beside the struggling youngsters. Worksheets have to display an awareness of these individuals' needs. They should also be appealing. A large typeface can be used or the number of words on the page limited -- a process necessarily extravagant on paper! Games, cartoons and competitions may be included to enliven proceedings. Such a sheet will require the cooperation and involvement of the school Resources Officer. Full duplicating services are essential. Several types of workcards, responding to the various ability levels in a class, should be available. Worksheets can be homemade, bought commercially or adapted from existing schemes. A list of schemes producing materials is given in an ASE publication. (13) Considerable expertise is required in the construction of worksheets; they must be challenging, able to reach the academically able as well as the slow learners and must create an in-depth attitude to learning -- quite a task!

With a worksheet approach there is more chance of individual verbal contact between teacher and student. The teacher can go round his class encouraging or cajoling pupils, discussing experiments, an item on the card or homework. It will facilitate better opportunities for the teacher to get to know his class, but at no time should the teacher spend too much time with one pupil, otherwise chaos could result due to unguided, undirected pupils becoming bored. However, this virtually implies teaching by proxy, via the worksheet -- surely an impersonal extreme to be avoided. On the other hand, lessons should not become hyper-organized so that the pupils perform in a robot-like way, to be switched on and off at the will of the worksheet.

We seem to have, so far, a year group divided into classes within which the pupils are working on several types of workcards of differing ability, trying with what often seems great singleness of purpose, sometimes with a great deal of success, to wear out the teacher. Therefore, it would be worth considering a system along the same lines of numerous ability-level classes within a year group, with pupils working on fewer levels of workcard. This system, not far removed from setting, would facilitate group and class cooperation and participation. It is not always desirable that pupils work for the major part of their time on their own.

The consultant role of the teacher can be extended into experimental work -- either through similar individual experiments or via a 'circus' method. The latter is less arduous, easier on facilities and prevents the more able pupil from getting to and doing all the experiments first. The least able, sometimes preceding them by this process, can become 'experts' and so receive a welcome confidence boost.

Team-teaching may add the flexibility and variety required by a class or group although this would necessitate careful timetabling and cooperation between the teachers as well as their willingness to put their teaching on view to colleagues.

Once tried and tested, mixed ability techniques via directed topics can form a standard approach to science teaching. (24) Should there be a national science program, not only with a common core syllabus now being instituted by examination boards, but a central syllabus with a common approach?

One of the main features that arises from any investigation into mixed ability teaching, or indeed any teaching situation, is the attitude, commitment and uniqueness of the teacher. The teacher-class-pupil relationship is paramount. "In each school each teacher must work out his own solution to his own particular situation." (19)

No two groups will be the same, and no two days identical.

"My class works well with my worksheets in my school and in my laboratory when they are taught by me." This would be a typical statement from many an established science teacher -- but a selfish one nonetheless.

There is no single solution that will cope with every type of problem in every type of school. A teacher needs a repertoire of teaching methods and techniques for a variety of occasions. Channels must also exist through other staff, schools or organizations, whereby a free-flow and interchange of often localized ideas, techniques, methods and resources can take place for the overall benefit of both teacher and pupil.

Assessment and Examination

The assessment of pupil success is just as important in the mixed ability set-up as in a streamed situation. The traditional rank order should be discarded in favour of gradings (for ability and endeavour) and comments. What ought to be noted and transmitted to the pupil is his or her progress. Subjective comments and judgments should not be overstressed; neither should they overshadow objective assessments. General comments on reports at their most dilute level can be a blur of non-committed nothingness from which pupil, teacher and parent can gain very little.

In the early years of secondary school, the more able can be encouraged to match themselves with individuals of a similar standing in other classes. This will provide an important stimulus for further endeavours. Extra work at a sufficiently taxing level must be available, perhaps in the form of relevant extra reading or project work, giving these brighter members of the peer group an opportunity to expand and develop their intellectual skills. Parental support is important. A major critic of mixed ability teaching is the parent of the Grade A child. He must feel that his child is being looked after.

The demands of our present examination system mean that, from the fourth year, pupils select option subjects, the number varying from pupil to pupil, school to school, as well as the core subjects -- English, Mathematics and sometimes a foreign language -- in which they will take external examinations in the fifth year at the age of sixteen. Syllabi and courses are standard, and pressures are such that changes in teaching patterns occur. Setting superseded mixed ability grouping, and theory lessons are introduced due to the pace set by the syllabus. The prolonged working style of discovery techniques are exchanged for a rapid assimilation of disseminated information. Some pupils, however, find the transition difficult.

To a major extent, the restrictions -- the formal O- and A-level examinations -- impose this problem on today's pupils. As long as our present society continues to use examinations to predict and assess possible future attainment, with respect to career prospects, teachers will be under stress from all sides to revert back to selecting out, at an early stage, those of their pupils who are going to succeed in their examinations. In this age of falling school rolls and subsequent school closures, the kudos a school can extract from these 'successes' may be instrumental in maintaining its school numbers or, indeed, ensuring its survival.

In England and Wales the A-level examinations, taken when pupils are in their second sixth form year, are a satisfactory base for university entrance. (25) Certain standards have to be achieved in these examinations for possible entry into higher education. Syllabi are devised with this in mind. Examinations are set similarly, yet how many students who take A-levels actually enter into higher education? Enough to justify the present situation?

In 1984, approximately one-third of the sixth form population -- 155,000 -- will be chasing 65,000 university places and a similar number of vacancies at polytechnics.

Choices of sixth form subjects often influence the way a fourth year pupil chooses his options. It must be asked, therefore, whether the effect of the university A-level requirements should extend back into the middle years of secondary school, so affecting the majority, when only a minority will actually have the opportunity to graduate from a university.

A dual system, namely a general course with matriculation at eighteen, assessed by examination but with the final certificate also having a subjective report phase, is one alternative. There are, however, many problems associated with non-confidential reporting unless standardized procedures are used. As well as this general system, another course could run concurrently -- or even better -- subsequently, for one year, specifically for those who want to aim for higher education. A 19+ examination for university/polytechnic aspirants could be geared and controlled solely for, and even by, the universities. Alternatively, the sixth form would comprise just the general component and be followed by a university degree extended to four years. Competition for places might reduce this general two-year course to a scheme again specifically catering to university entrance, with a subsequent alteration in syllabus and emphasis.

Various published proposals on how the existing examinations system could be changed, the Q and F, N and F examinations produced by the Schools Council and the Standing Conference on University Entrance in 1972 and 1973 are summarized by Dean and Choppin. (26) The topic as a whole has been lengthily discussed during the last ten years but, as yet, little has been done to adapt or change the present examination system.

It is often found in science that, even when the sixth form course is constructed along discovery lines, as the Nuffield Secondary Science courses are, the limits imposed by the need for success in examinations, which for the most part test memory only, reduce to a minimum and assess minimally any progress the pupil may have made in learning skills and techniques, which will stand him in very good stead in later life. Sixth form groups are often of very mixed ability across the academic range. It is an ideal environment for an individualized learning technique, with groups usually being small and more resources available. It is, however, built around lectures or formalized lessons followed by associated practical sessions and, in some schools, little of the latter is incorporated. Even specifically designed courses (Nuffield) are not structured sufficiently to cope with the ability range that can exist.

New Pressures in the United Kingdom

Recently, new methods of approaching science have been developed. TVEI (Technical Vocational Education Initiative), developed by the Government but as yet limited to pilot schemes, is a resource-based program. STS (Science, Technology and Society) is a course with similar connotations. (27) It is encouraging to see the continued development of the CPVE

(Certificate of Pre-Vocational Education) and the cooperation between BTEC (Business and Technician Education Council) and CGLI (City and Guilds of London Institute) in producing vocationally-based courses for post-16 year olds is an initiative to be welcomed.

These systems are resource-based, are expensive to run and require not only considerable expertise, but training or retraining on the part of the teacher. Yet this approach is the very one that we would recognize as being along the objective guidelines of science education.

With the present-day monetary constraints on education, the implementation of a satisfactory comprehensive teaching method is effectively restricted. Smaller classes are not possible, due to the principles of cost-effectiveness, and resources are often depleted or diverted for the same reasons.

In this micro-chip age, effective science teaching still depends very heavily on the often overloaded teacher. What is asked of that teacher is that he be constantly aware of his teaching. The teacher is no longer just an instructor but an investor, an innovator, an instigator and, above all, an inspiration. He must also be totally and professionally committed, in that he must be willing to find ways of overcoming underachievement, encouraging his pupils to develop to their full potential.

The school is a teacher-based institution. It is through the medium of the teacher that the pupil learns, even if by proxy through a worksheet! The teacher should realize this responsibility and be prepared to change and be changed in response to these obligations. "Capable of adapting and adjusting" -- these profound educational aims, set down by the Plowden Report, are as applicable to the teachers as to their charges.

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SCIENCE AND HIGH TECHNOLOGY MINORITIES AT RISK IN TOMORROW'S SOCIETY

Introduction

Recently, significant emphasis has been placed on new and emerging high-technological occupations as well as the need for a scientifically literate constituency. This paper will focus on minority students and their need to be scientifically literate along with some solutions to this problem. Hispanics and North American Indians are the most underrepresented minorities in the science and engineering arena. Thus, this paper will concentrate on the needs of Hispanics and North American Indians as well as other minorities.

Data Concerning Minority Students In Secondary, University and Graduate Schools

The data from Table 1 suggests that success (which in this paper is equated with graduation) is not as high for minority students as it is for non-minority students in a secondary, university, or post-graduate setting. (6)

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GRADUATE FROM

	High School	College	Graduate School
Whites	83%	23%	8%
Blacks	72%	12%	4%
Hispanics	55%	7%	2%
North American Indians	55%	6%	2%

Table 1 Percentages are of the number of students which have entered high school in each group. Information derived from "Queremos Lo Mejor Para Nuestros Hijos/We Want The Best For Our Children." (6)

If you are white, you have an eighty-three percent chance of graduating from a secondary setting whereas blacks have a 72% chance, and Hispanics and North American Indians a 55% chance, approximately.

The same pattern persists at the college level; more whites are successful than are minorities. Of the 83% white high school graduates, 38% will enter college, and of these, 23%

percent will finish college. For blacks, graduation from graduate school is only one half as successful as for whites, and for Hispanics and North American Indians, only one fourth.

What is interesting to note about the figures in Table 1 is that the more knowledge a minority student endeavors to acquire, the lower his chances become for graduation.

Statistics Concerning Minority Engineers and Scientists

In 1972 The National Science Foundation (NSF) reported that only 4% of the scientists and engineers in the United States were from minority groups. (13) Of the 4%, 60% were oriental, 30% were black, and the remaining 10% were other non-whites, primarily Hispanics and Native Americans. (13) An update of the 1972 information provided by the NSF shows that in 1978 and 1979, 152,104 bachelors degrees in science and engineering were awarded. (13) Of these, only 4,189 were awarded to Hispanics. (13) The NSF report shows that of the 25,827 masters in science and engineering degrees awarded, only 442 were to Hispanics. (13) The same NSF report showed 8,139 Ph.Ds awarded in science and engineering, and only 92 went to Hispanics. (13)

Implications Derived from Statistics

From the aforementioned information, the following conclusions can be gleaned:

1) There is an extremely low representation of minorities in institutions of higher education.

2) There is an even lower representation of Hispanics and North American Indians in institutions of higher education.

3) Minority students (especially Hispanics and North American Indians) are not engaged in the precollege academic paths that lead to engineering, mathematics or science programs in institutions of higher education.

The effect of this dearth of minorities in institutions of higher education is that there is a low representation of minorities in scientific and engineering career fields. There is an even lower representation of Hispanics and North American Indians who are professional scientists and engineers in today's work force.

Obviously, if there is a lack of minorities studying science and engineering in colleges and universities, there will be a lack of minority scientists and engineers in the work force. The NSF report substantiates this conclusion. In 1978-1979, 1,844,000 scientists and engineers were employed. (13) Of the 1,844,000, only 16,600 are classified as "other" (Hispanics and North American Indians). (13) This appallingly low figure represents 0.009 % of the employed scientists and engineers.

For minority populations, two problems arise. Most obviously, there is a low representation of minorities (some lower than others) in scientific and engineering fields. Furthermore, the NSF data suggests three basic questions: 1. Why are so few minorities (especially Hispanics and North American Indians) acquiring scientific literacy in the schools? 2. Does a lack of scientific literacy at the precollege level prevent minorities from participating in important affairs of society, such as high-technological and scientific jobs? 3. Does a lack of scientific literacy prevent minorities from participating in the decision-making process concerning societal issues?

Need

There must be a immediate attempt to resolve the science education needs of minority students. Not to recognize and attempt to resolve these needs is tantamount to developing a policy that consciously discriminates between those citizens who are to become scientifically and technically literate and those who will not.

At least for the United States, this would be in direct violation of the National Science Teachers Association's (NSTA) aspirations. The recent NSTA position statement reads, "The aim of science education for the 1980's is to develop scientific and technological literacy for all citizens." (14)

Discussion

The current crisis in science education is not new for minorities. Otherwise, there would not be a disproportionately low representation of minorities in the engineering, mathematical and science fields. Today, with the changing economy and new and emerging high-technology fields, it is imperative that minority students are offered the same opportunities as other students to develop the rudiments necessary for becoming scientifically and technically literate in order to guarantee successful social participation in the future. In order to do this, the first hurdle that minority students must overcome is an educational system geared to the so-called average learner. (2, 15, 18) For example, research indicates that most recent science curricula have been produced only in English. This dearth of materials continues to foster disparity for language-minorities in science, mathematics and engineering achievement based on English language ability. (10)

The most obvious question to the aforementioned statements is "how?" How can science educators meet the needs of minority students, and how do science educators develop scientific and technical literacy in minority populations?

Before I address the idea of how to meet the needs of minority students, let me suggest that solutions are sometimes easier to develop than resolutions. Inherent in resolutions is the acceptance of all the factors that have led up to the creation of a problem. What are some of these factors? There are cultural factors, language factors, attitude factors, material factors, methodological and technique factors, testing factors, etc. (2, 7, 15). Not only do we have these factors, (which translate into varied learning styles) but because of socio-economic and political reasons, there has been an even greater increase in the variety of learning needs present in our classrooms. (2, 13)

For example, within the last decade the United States has seen a dramatic increase in the number of minorities. Asian-Pacific Americans have increased 128%, blacks 17%, Hispanics 61%, and North American Indians 71%. (11) If you compare these increases with the total increase of the population of the United States(11.5%), Asian-Pacific Americans (who are at the highest end of the spectrum) are increasing ten times faster than the total population of the United States. (11)

Consider the following: minority students have positive attitudes towards science, yet some minority groups (especially Hispanics and Native Americans) are experiencing a critical shortage of representation in our institutions of higher education and in the professional world. (4, 13) This is an extremely strong indictment; our system discourages minority students from pursuing courses and careers in engineering, mathematics, and science. (4) This brings me back to the statement that solutions (appeasements) are easier to come up with than are resolutions. Science educators do not want to admit that they are part of an educational system that does such a good job of appeasing, and thus discriminating against, a group of people rather than accepting their diverse learning needs.

General Curricula Needs

The saying that there are two sides to every story is especially true in this case. One side of the story is the life that a student has before he/she ever enters school. These are the socio-familial influences (which to that point and presumably thereafter have shaped that particular individual). The three most prevalent influences are culture, language and socio-economic status. (8)

On the other side of the coin, is the educational system, which for some students perpetuates the same socio-familial status to which they have become accustomed. In other words, school becomes an extension of the student's home. The curricula is designed around the same values, language and ideals that are found in the student's home. Thus, for this student there is a continuum of socio-familial influences. But for the student who does not have the same socio-familial experiences, which the educational system embraces, there is no such continuum.

Therefore, the first step is to develop an educational system which reaches out to all. The second step is to incorporate a philosophy (from which curricula is developed) into the general framework that recognizes variations in culture, language, and socio-economic factors. It is not an easy task that I am advocating, i.e., a system where one's differences (educational needs) dictate what one's education will be. Where do we begin?

Meeting the Learning Needs of Minority Students

The objective advocated is to improve the quality of science education by meshing together what is being taught and the varied learning styles (learning needs) of students. There are many ways science educators can meet the learning needs of minority students. I would like to suggest emphasis in two areas. One is to incorporate into science education those methodologies and techniques that have been found to be successful among minority students. The second is the development (and continuation of current programs) that offer tutorial assistance and psychological support.

Methodologies and Techniques

A research effort was conducted from 1966-1983 that was concerned with teaching science to language minority students. Six conclusions were derived from over 200 resources. They are as follows:

1) Bilingual students scored higher on the quality of scientific hypotheses.

2) Handbooks help students for whom English is a second language.

3) Illustrations and activities assisted students in mastering new terminology.

4) A teacher's guide was as helpful to the teachers as illustrations and activities were to the students.

5) Students did prefer a bilingual as opposed to a monolingual environment.

6) Humor, discussion, and student participation were found to be more helpful than classroom drills. (2)

Other techniques and methodologies found to be successful in teaching science to minorities:

1) Make science meaningful by incorporating the student's world. (7)

2) Allow students to learn and explore with you. (7)

3) Develop activity-based science programs. (12)

4) Develop communication activities which allow students to use their language. (2, 12)

5) Recognize that all students are not white Anglo-Saxon Protestants. (1)

6) Minorities can be successful as engineers, mathematicians and scientists. However, motivating efforts need to be incorporated into a science teacher's lesson. (16)

Programs That Affect Tutorial Assistance and Support

1. EQUALS. University of California, Berkley. This is a program that, through inservice training, exposes teachers to problems encountered by women and minorities and helps them encourage these students in mathematics.

2. Pre-Freshman Engineering Program (PREP). California State University, Northridge. A summer program in which minority students do advanced and remedial work in mathematics and science. Females and minorities are also encouraged to study mathematics. Fifteen of these programs are funded by the U.S. Department of Energy and twenty-six colleges.

3. Orbit '81. Camden, N.J. Camden High School, in conjunction

with RCA, has initiated a program that develops interest in science among minority students.

4. Texas Alliance for Minorities in Engineering, Inc. A program operating at the junior and senior high level in fifteen locations throughout the state. Schools work in cooperation with business and industry to develop enrichment programs for talented minority students in mathematics and science.

5. Mathematical, Engineering, Science Achievement (MESA). University of California, Berkley. MESA is a tutorial program for junior and senior high students. It is designed to give academic support for minorities via study sessions, tutorial assistance and summer enrichment programs.

Conclusion

"In America our strength is our diversity." (3) In order for us to remain strong, we must develop all of our socio-resources (culture, ethnicity, native speakers of languages other than English) to the maximum.

Change in science education should incorporate the curricula, methodologies, and techniques that ensure scientific literacy for all. This can be accomplished via a threefold plan:

1. To ensure that all students, regardless of race, culture,

language and/or socio-economic status, are offered access to the same educational opportunities.

2. To ensure that all students, regardless of race, culture, language and/or socio-economic status, are encouraged to pursue the science and mathematical courses necessary for careers in engineering, mathematics or science.

3. To ensure that all students, regardless of race, culture, language and/or socio-economic status, are provided with the tools necessary to make decisions in the areas of science and high-technology which effect society and its citizenry.

The key to the success of this threefold plan is to approach minority students with the desire to accept (i.e. incorporate their differences into the general educational framework) and not appease them.

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Discussion: Meeting the Needs of A Diversity of Students

Plenary
Glen Aikenhead, Rapporteur

Question: Are you advocating mixed ability grouping?

Answer (D): Yes, independent instruction except for the children who do not respond to individualized instruction. These children should have the regular type of group learning.

Comment: The real world is a world of mixed ability, and school should be a microcosm of the real world.

Question: Students do math and science in class. Should students do science in other classes?

Answer (D): Yes. Teachers should cooperate to give students the richest experiences.

Comment: Lower ability students require science teachers with the greatest competency.

Comment: The term 'mixed ability' may imply a fixed intelligence, therefore it is better to use the term 'mixed attainment' and 'mixed motivation' when describing student attributes. Mixed ability is multifaceted; it has social and cultural dimensions as well.

Question: The social and cultural backgrounds of immigrants to the U.S. are also different from the mainstream society, but are they more different than poor working class students' background?

Answer (G): The difference is about the same.

Question: What is the distinction between 'solution' and 'resolution'?

Answer (G): 'Solutions' are band-aid reactions to a problem while 'resolutions' are the admission that there is a problem plus a reaction that gets rid of the problem.

Question: Why have Asian-Americans been so successful at getting into science?

Answer (G): U.S. citizens have expectations (bias) that they are good at science and at doing academic work in general. (However, industry claims they lack social and communication skills.) Other factors include parental support and adult role models.

Comment: In order to help educational minorities advance in society, perhaps science and technology are not the paths to follow. Perhaps accounting and law are better for educational minorities. Information technology is better than bridge building for girls, for instance.

Answer (G): All minorities ought to have a chance to make that decision rather than simply meeting society's assumed expectation for minority members. The comparative success of black students over the past fifteen years was attributed to their political organizing. Cultural differences among minorities have been researched. Interests and ease of manipulating nonverbal symbols can be found in some subcultures. Thus these members would have a tendency to do better in math and science.

A discussion followed the group reports:

Out of school activities, e.g., museums, TV, institutes, could encourage minorities into science. The teacher's role is two-fold with different consequences:

a) central as the decision maker on matters of curriculum and instruction.

b) facilitator as in the style of teaching.

Group I

Jo Piotrowski, Rapporteur

A) Topics discussed: Durrant paper

1. All students must have physics. There is a need to assess the abilities and then adapt instruction and curriculum to deal with the different abilities. We should not teach with the assumption that all students are future scientists. Also, even the academically oriented "future scientists" must receive more practical, concrete, real-life applications of the science concepts.

2. Who should be responsible for teaching issue-based science? We science teachers can share the responsibility with other disciplines (technologists, social studies, industrial arts) without giving up our primary responsibility. Teaming is useful.

3. Motivation is not necessarily a possessed property. It may result from the special interaction of student/teacher/room/materials. We teachers have a responsibility to motivate.

4. The department head's (and other immediate administrator's) philosophy and methods have significant impact on the content and quality of teaching.

5. Teachers play an important part in the development of a student's self-esteem and must be aware constantly of that role. Eye contact, for example, with each student each period is essential.

6. In addition to instructional review and improvement, there is need for curriculum review, which is happening presently at a national level in the UIC.

7. Exams often don't deal with the social implications of material covered. They should be written to encourage opinion supported by fact.

8. Evaluation of students should be expanded to include an element of "significant participation" and oral testing.

B) Topics discussed -- Guillard paper (Minorities)

1. Teachers must cope with the cultural impacts of background on a student's approach to such things as logic, creativity, and homework.

2. Obviously, if a student can't speak the language, he/she can't understand the concepts. Therefore, we need to provide a multi-lingual presentation while students are learning the language.

3. Teachers should accept the diversity and welcome it and not see it as a barrier.

4. There should be a dissemination of existing research about the cultural and economic influences upon problem solving and thinking processes.

5. The influence of primary/elementary teachers is very great; it should be used to mold positive attitudes toward learning.

Summary

We believe that all children can learn if they want to, and thus science teachers are partly responsible for motivation.

1) It is important for teachers to make other teachers and administrators aware that there is a solvable problem in dealing with a diversity of learners.

2) We recommend that our associations encourage teachers to understand the diversity of backgrounds and motivations in students and to change instruction, not just curriculum, by:

a) sharing present research on learning styles (age/culture)

b) increasing amount of research about the above

c) requiring different kinds of in-service and pre-service training for teachers.

d) developing and sharing case studies of exemplary programs and techniques that are working

e) taking a course that the teacher finds difficult and using that experience as a "low ability" student to improve his/her teaching style

3) It is important for teachers to increase relevance by reference to day-to-day life experiences by:

a) increasing discussion across disciplines

b) calling on other disciplines to share the responsibility of referring to so-called "science topics"

c) tying in practical, environmental activities constantly

4) We recommend that our associations continue to be involved in reviewing curriculum, establishing guides based on information obtained by research.

Group II
Dr. C. N. Harris, Rapporteur

The Needs of a Diversity of Learners

We felt that staff appointments should reflect the percentage spread of minority groups and ethnic groups in schools -- the dilemma is that the system does not provide suitable staff of the right background -- there can only be the principle that you choose the best person from the short list of candidates. It was felt that Professional Associations should give guidance and help in creating answers to the problems of minority groups.

These are three questions that must be satisfied -- do we keep minority groups intact or integrate them into the majority or let them choose. In-service training should help teachers recognize, plan and react to the educational needs of minority groups -- there can only be one key formula -- "Don't label groups; treat and be sensitive to the needs of each child as an individual."

In the UK, immigrant parents want their children to have identical treatment for rapid assimilation into the school.

The main problem is that teachers cannot leap out of their own culture and "like begats like" -- advisers cannot give simple, condensed advice on the features of, say, a West Indian child so the alternative is for teachers to find out for themselves directly from the minority child.

It was noted that minorities live in enclaves and are well-adjusted to each other when younger but that as they grow older, they split up and segregate into their own Greek, Jewish, Jamaican, Indian groups.

It was recognized that teachers in the UK in their PGCE were trained in a subject-orientated and not population-oriented way and that this was undesirable.

The role of US counsellors was discussed, but there was no equivalent in the UK system because UK teachers were not only subject specialists but career advisers, pastoral guides, discipline trouble-shooters as well. It was an expected quality of a UK teacher that he/she was wholistically sound, mature and wise in his teacher role.

It was stressed that children must never think of themselves as failures or as minorities. There were reports of ways in which children visit Mosques, Temples, Synagogues and Catholic Churches so that barriers could be broken and they could all glean from their visits a better understanding of their peers in minority groups.

There was a strong difference between the US/UK systems regarding examinations. Since the 1980 Education Act, all schools now publish examination results in the UK and publish brochures for parents. These yardsticks eventually label the school and the final choice of the parent; this increased awareness of examination results was desired by parents for the future employability of the children in that school. Consequently, theme approaches such as "water," or "spirals" are excellent strategies, which cross subject boundaries for 11-13 year old children in their Math, Science, Geology, Geography, Language development but, after 14 years, they then embark on quite rigid courses geared to the examination syllabus in the UK.

This contrast between USA and UK systems was strong, and it was refreshing to understand the needs and patterns of the two sides of the Atlantic.

Group III
Alice J. Moses, Rapporteur

The committee outlined four major topics related to the papers:

1. What do we think are the issues?
2. What can research do?
3. What policy and changes are needed?
4. What can NSTA/ASE do to promote a change?

The first issue discussed was mixed grouping versus streaming. The group felt mixed grouping was more desirable for the following reasons:

1. mixed grouping is highly social; children get together to mingle. It permits children from different socio-economic backgrounds to come together.

2. less stereotypical -- does not label children, does not destroy self-respect.

3. avoids undesirable behaviors.

"How do we handle mixed ability teaching?" It was determined that teaching should be approached from issues that lead to content development. The issues should fit the needs of the local community but also address national and global issues. In handling mixed teaching, the approach should be eclectic and include a mix of the following:

1. whole group teaching
2. individualized teaching
3. collaborative teaching
    a. i.e., teams, games, tournaments
    b. interaction with technology should be included in the process.

The program of science instruction at Wausau High School was described and discussed in relation to collaborative teaching.

The discussion of minority education was brief; the following points were highlighted:

1. role models for ethnic groups
2. background materials -- making materials available
    a. NSTA has materials available
3. need for encouragement
4. acceptance rather than appeasement

"What do we want science to accomplish?" It was suggested that a system be designed after a decision is made on what the curriculum should be. It was felt that science curricula should share in common with other subjects and that science education should contribute to solving the wider problems in education.

Group IV
V. Payne, Rapporteur

Concerning the under-representation of minority groups and women in scientific and technological jobs, it was felt necessary to clarify whether this shows a difference or whether it is a problem. Is a problem needing treatment. How do we convince others to address themselves to it, and what methods do we use to try to solve the problem? Do we withdraw the group and give it special treatment, or do we allow for differences in a communal programme? However, whatever method is used, the very act of highlighting the group can lead to a backlash as the U.K. Scheme, "Girls into Science and Technology" has shown.

We set our goal as the "interested" student, acknowledging that in this joint venture, good teaching leads to an "interested" student. We put forward the following curriculum model. In one year it was suggested that thirty different concepts or patterns of ideas be explored. On each, different 'packages' should be available for different pupils, allowing for differences in understanding, background, etc. -- in other words, the materials should match the pupil. We saw the pupils as self-selecting the materials, with help from the teacher, and following an individualized learning programme. However, at any one time, all pupils would be working on the same concept or pattern of ideas although in their own individual ways. This was seen as essential for the survival of the teacher so that there would not be a multitude of dimensions with which to cope.

It was essential that information and insight from research be available to persons involved in the production of these 'packages.' Various initiatives in that area were welcomed. Firstly, in the U.K. the Secondary Science Curriculum Review (S.S.C.R.) collected examples of "good practice" and found solutions to various problems. The results of this are to be published in 1986. There is a similar initiative in the U.S. Secondly, results from the Assessment of Performance (A.P.U.) were being used in a follow-up project called "Children's Learning in Science" in which pupils' alternative frameworks and misconceptions were taken into account. Thirdly, information from research findings on learning styles should be used. However, in these last two areas, while the information is available, it is not necessarily readily accessible to the teacher, either physically or in a 'language' easily understood by the practicing teacher. It was suggested that the Association journals and publications should include "edited" versions of important research findings.

"Being interested" is very much part of the 'self-esteem' of the pupil. It was observed that, for the most part, the low self-esteem of the low achieving pupil reflected the low self-esteem of the family, and this was an aspect that might have to be taken into account. However, we brought ourselves back into the school and addressed ourselves to the question: How can we increase the self-esteem of the pupil through science instruction? It was seen that we need to design for success and acknowledge the central role played by the teacher in enhancing the pupil's self-esteem. The 'enhancing' teacher would have a repertoire of skills and qualities including the following:

1. He or she works on self-esteem, both directly and indirectly, through the curriculum.

2. He or she sets goals clearly, and the pupils know what those goals are.

3. He or she teaches towards those goals.

4. He or she evaluates, initiating self-assessment for the pupil to give feedback on progress towards the goals.

5. He or she remediates, acknowledging and discussing misconceptions and helping to put them right.

6. He or she minimizes interruptions in the classroom and maximizes the time spent on the task.

PART IV

RESEARCH IN SCIENCE EDUCATION: IDENTIFYING NEEDS AND RELATING RESULTS TO PRACTICE

Papers by:

Malcolm Frazer
James Robinson

Discussion

Professor Malcolm J. Frazer
Dean of the School of Chemical Sciences
University of East Anglia

RESEARCH IN SCIENCE EDUCATION
IDENTIFYING NEEDS AND RELATING RESULTS TO PRACTICE

1. INTRODUCTION

Improvements in the teaching and learning of science are so important that they should not be left to chance or personal intuition, but should be firmly based on the results of research. The purpose of this paper is to assist in identifying the most important areas for research in science education and to promote discussion on how best the results of research can be converted to practical use.

Curriculum development and the production of new teaching aids are not included although there is no clear distinction between research and innovation. Research should form the basis for innovation, and the subsequent evaluation of innovation is part of research.

The essential theme of this paper is that science education research is not just a matter for a few education researchers, but that all science teachers could, and should, be involved in some way with research related to the teaching and learning of their subject. The view that the teacher has an essential and

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continuing role in research was initiated and developed by Stenhouse. (1) However, it is not the intention to limit this review to small scale or "action-based" research. Some problems in teaching science can only be resolved by large scale projects or by more fundamental research.

This paper is a survey of what is being done and what needs to be done in science education research and is not in any way intended to be a presentation of the results of current or past research.

2. MODES OF SCIENCE EDUCATION RESEARCH

Science teachers can become involved in research in three ways:

(a) by leaving science teaching and becoming full-time researchers;

(b) by taking a higher degree course, which involves presenting a dissertation on a research project;

(c) by undertaking research in school as an intrinsic part of the teaching function.

There is overlap between these three modes. At the present time (1984) in the United Kingdom, most science education research is undertaken by mode (b). There are opportunities for science teachers to take Ph.D., M.Phil., M.Ed. and M.Sc. degrees on a full-time or part-time basis. The Ph.D. and M.Phil. degrees are entirely research degrees and normally take three years and two years respectively on a full-time basis and about twice as long on a part-time basis. The M.Ed. or M.Sc. degrees take one year full-time and two or three years part-time. In some institutions, these Masters degrees are also entirely research degrees, but more commonly an M.Ed. or M.Sc. in science education involves a combination of course work and a small research project. A list of the higher degree dissertations and theses in science education from the United Kingdom is published annually in Studies in Science Education.

About fifteen universities or polytechnics in the UK offer facilities for higher degrees in science education. In these institutions there is a nucleus of academic staff to supervise the research, and in some there is sufficient level of research activity that there is a permanent research staff (mode a). It is desirable that such staff have former teaching experience.

It is very unusual for UK school teachers to have more than a one-year secondment, and so full-time Ph.D. students are either from overseas or are working under mode (a). Whenever possible, overseas students should work on projects associated with problems of science teaching in their own countries.

Centres for modes (a) and (b) are normally in departments of education, but there are one or two centres based in subject departments (e.g., there are science education research groups in chemistry departments at East Anglia, Glasgow and York). There are currently ten chairs of science education in the UK.

Some of the higher degree courses in science education have now been operating for over fifteen years, and although a number of the graduates will have been overseas students or will have moved away from classroom teaching, there must now be several hundred practicing science teachers with science education research training and experience. It is these teachers who must provide the leadership if science education research by mode (c) is ever to become widely established. Hopefully, those who have taken higher degrees will want to continue investigations as a natural part of their role as teachers. Other conditions for an expansion of mode (c) are: (i) that education authorities make time and resources available, (ii) that the centres involved with modes (a) and (b) provide guidance and expertise on research methodology, and (iii) that some form of recognition is given to teachers who enhance their teaching by research and contribute to research by teaching.

Questions

(1) How can teachers who have had science education research

experience and training be encouraged to continue research activity as a natural part of their teaching function? What are the barriers?

(2) Are there alternative models for science education research other than those outlined above as (a), (b) and (c)?

(3) Is it desirable and achievable that every science teacher should obtain some experience in science education research?

3. IDENTIFICATION OF RESEARCH AREAS

The list that follows is centered on the secondary level (approximately 12-18 years age range), but most of the areas do relate also to the primary and tertiary levels of education.

3.1 Research focused on learners

The largest volume of science education research is in this area, which is not surprising because education is about the learning (development of knowledge, skills and attitudes) of individuals. It is this area of research that uses the theories and methods of psychology. There is a useful, brief overview of the contributions of psychology to science education.(2)

3.1.1 Students' difficulties

The teacher's task is to promote learning, and to do this effectively there is a need to find out which concepts, principles and skills the students find difficult. More importantly, having identified the difficult areas, the teacher needs to know why they are difficult and what can be done to overcome the difficulties. Studies of examination papers, specially designed tests and students' essays, as well as questionnaires and interviews, are some of the methods used. There is no clear division between this and the next area (students' misconceptions). The research methods are the same.

3.1.2 Students' misconceptions (alternative frameworks, children's science)

It is easy to fall into the trap of thinking that until a teacher presents the first lesson on topic x, the student's mind is devoid of any ideas related to topic x. This is far from reality, and it is likely that every child approaching a new topic already has some ideas about it. These ideas, or alternative frameworks as they are often called, may be correct (on the basis of the currently-held scientific theories), partially correct or incorrect. The teacher needs to know and to help the learner build on, develop or change existing ideas. Of course, each child is unique, but research reveals that there are some commonly held ideas about scientific words and concepts among children of particular ages. An excellent review of some of the methods and results in this area of science education is in the book The Pupil as Scientist by Rosalind Driver. (3) Teachers who ignore this type of research are simply making their task more difficult. The simple notion that the role of a teacher is not to fill a vacuum, but to provide opportunities for a child to adapt and expand on existing ideas, is very important, and once grasped can alter the whole approach to teaching. There is much research the teacher can do in this area. Each new class and each new child provide further opportunities for research.

3.1.3 Cognitive development

This area has been very popular in the recent past, but interest is probably declining. The essential idea, based on Piaget's stage theory of cognitive development, is the need to match the conceptual demands of knowledge and skills in the curriculum to the cognitive stage of the learner. The book by Adey and Shayer, Towards a Science of Science Teaching (4), contains a strong case for this type of research and presents results. There is a strong link with research area 3.2.1 -- concept mapping.

3.1.4 Language and science education

It is rewarding to study the language used by (i) students as they write about science, (ii) students in their attempts to discuss science with fellow students or teachers, (iii) teachers during lessons, and (iv) text-book authors, work-sheet writers and curriculum developers. Such studies give insight into how students learn and why they so often fail to learn. This area of science education is strongly linked with linguistics. Some of the techniques are simple for the classroom teacher to apply, e.g., determining the reading age level of a text-book, but others (e.g., linguistic analysis, application and analysis of word association tests) are more complex, less well developed and certainly require the classroom teacher to be trained and to have expert guidance. There are overlaps with research on: (a) learning difficulties and alternative frameworks, where language studies are used as a tool to probe students' conceptual development (cognitive structure); (b) concept mapping (3.2.1) and (c) classroom interaction studies (3.3.1). One other subject for research which might be included under this heading is the study of children learning science in a second language. This is becoming increasingly important as communities become more culturally heterogeneous. The area of cross-cultural studies in science education is too specialized to be considered in this survey, but here again language is an important tool of analysis.

3.1.5 Problem solving

This might have been included in 3.1.1 as a skill that students find difficult, but many teachers and researchers consider problem solving such an important part of science education that it is listed separately here. The design of experiments, open-ended problems, laboratory problems, library and data-base problems, as well as "closed" paper and pencil problems are all included as part of problem solving. Some of the research questions about problem solving that need answering are the following.

For particular types of problems, how do the approaches of experts and novices differ? Why is it that students, who apparently possess all the knowledge and skills necessary to solve a problem, are unsuccessful? What are the successful strategies for problem solving? How important is confidence? (see 3.1.6) How can problem solving best be taught?

Research methods and some results, particularly about developing problem solving skills in chemistry, have been reviewed. (5) One aspect of problem solving research is to use information processing theory in which the human problem solver is likened to a computer. (6) Often students fail to solve problems, or more generally fail to learn, because they are attempting to handle too much information at the same time. Research (7) has generated useful ideas for teachers on how to reduce the information load on students.

3.1.6 Attitudes

This is a large and difficult area of research. (8) It is concerned with motivation, with the level of interest students show in the sciences and with styles of learning (cognitive preference). Of special interest in the UK at the present time is the attitude of girls toward studying science. (9) Probably more important than probing attitudes are action-based programmes such as Girls into Science and Technology (GIST). (10) In addition, teachers also need to know how best to develop scientific attitudes (e.g., curiosity, objectivity, and a desire to ensure that science is used for the benefit of mankind). It is necessary to express caution about research in the area of attitudes. Although it is relatively easy to accumulate data about attitudes, there is often considerable doubt about the validity of the questionnaires and interview schedules.

Questions

(4) What are the most difficult topics and skills for students to learn in science?

(5) How easy is it for teachers to obtain some idea of the alternative frameworks in a class of pupils before starting to teach a new topic?

(6) What is the future of research on cognitive development?

(7) What research could teachers do to reveal the level of language they use in their classrooms in the spoken word, in

work-sheets and in the text-books they recommend?

(8) How far are the questions about problem solving raised in section 3.1.5 general, and how far do the answers depend on the type of problem and the subject area?

(9) How can the validity of attitude questionnaires and interview schedules be improved?

3.2 Research focused on the subject

3.2.1 Concept mapping

For effective learning, teachers and learners need to appreciate the structure of their subject. They need to see the relationships between the facts, concepts and principles within the subject. As yet there is no generally accepted approach for obtaining a concept map or, as it is sometimes called, "content structure." What is needed is an easily applied routine for teachers to use to obtain a view of the logical sequence of the concepts to be taught. The various methods currently available have been reviewed (11,12,13), but much more remains to be done.

3.2.2 Incorporation of new scientific knowledge into existing curricula

Scientific knowledge is ever growing, and to ensure that science courses do not stagnate and that they are preparing students for future needs, it is important that new scientific discoveries and technologies are included in syllabi. Deciding what among the mass of new knowledge should be included and in what form; and equally important, what should consequently be left out, is not a simple task. It requires expertise in the subject, understanding of what is possible to be taught, and judgment. The exercise of expertise and judgment is surely research, and yet for most teachers and education researchers this is a largely ignored area.

Questions

(10) What methods are available for determining the content structure of instruction? Is it too soon to be searching for commonly accepted procedures?

(11) What are the criteria and procedures for determining which new knowledge should be incorporated into syllabi?

3.3 Research focused on teachers and classrooms

3.3.1 Classroom interaction

Most formal education takes place in classrooms or laboratories. These are very private places, but if teaching and learning is to be improved, we need to have objective methods of recording and analyzing what goes on in them. There is a useful and critical review of classroom interaction studies. (14)

3.3.2 In-service education of teachers

There is an urgent need for greater provision of in-service courses for science teachers. The current policy in the UK to have a balanced science curriculum for all students to the age of sixteen has major implications for in-service education. Research is needed to discover appropriate styles and content for in-service courses, and to find out why so many science teachers resist any form of further study.

3.3.3 Effects of safety legislation

This is a small area but nevertheless one which requires investigation. It is often claimed that recent safety legislation and its interpretation in the form of local rules and regulations has inhibited the quantity and quality of science laboratory work, but objective studies are needed to find out if this is true. Research is also needed to see whether the increased legislation has made any difference to the awareness of hazards and to developing more favorable attitudes to safety matters by teachers and students.

3.3.4 Effects of inflation and/or cuts in school budgets

There is very little objective evidence about this. It would be useful if there was an on-going research project that produced hard evidence on the nature of the changes occurring in school science as a result of reduced resources. The effects will, of course, vary from area to area. Has the amount of laboratory work decreased? Are students being forced to use out-of-date text-books? It is bad for morale in the education service if allegations are made that are based on anecdote or suspicion rather than on hard evidence. With proper research evidence, a case might be made for increased funding for science and technology education. But such a case would surely fail if based only on rumor and opinion.

Questions

(12) How effective is classroom based research as a form of in-service training?

(13) What are the most suitable forms of in-service training for science teachers?

(14) Is it worth establishing in each region an objective study of the effects of new safety regulations and of cuts in educational expenditure?

(15) Are present laboratory courses effective? Do we obtain value from the money currently spent on laboratory work?

3.4 Research focused on assessment and evaluation

3.4.1 Graded tests and criterion referencing

The current moves in the UK towards these forms of assessment are going to require much research. The work of the Assessment of Performance Unit (15) has already had considerable impact. Work of this kind will need to continue, but there will be much to be learned by small scale experimentation with graded tests, criterion referencing and profiling at the individual school level.

3.4.2 Alternative forms of assessment

Opportunities should be taken to experiment with other forms of assessment. In particular, in the UK very little use is made in science education of oral testing. What are the advantages and disadvantages of this method?

3.4.3 Evaluation of new curriculum and new teaching methods

Innovations in science education should be evaluated. Important areas of change at the present time are: (i) the introduction of programmes and curricula relating science and technology to everyday life; (ii) the different ways of exploiting microcomputers in science teaching; (iii) the development of low-cost experiments using improvised apparatus and local materials; (iv) out-of-school activities. Evaluation is a skilled task, and evaluators need training and guidance. The style of the evaluation depends very much on the purpose. There are times when the style of measuring how far pre-defined goals have been achieved is suitable and times when a more naturalistic, descriptive approach would be better.

Questions

(16) How can classroom teachers contribute to the research needed for developing graded tests, profiles, etc.?

(17) Is it worth exploring alternative forms of assessment such as oral testing?

(18) Is it feasible for teachers to evaluate their own innovations?

(19) What are the criteria for defining approaches to evaluation for particular situations?

4. RECOMMENDATIONS FOR RELATING RESEARCH RESULTS TO PRACTICE

(1) The essential idea in this paper is that research will be

put into practice if results are obtained by classroom teachers. When this is not possible, then at least teachers should be initiators of the research problems and should be involved in regular discussion with the researchers. There is an urgent need to develop closer forms of collaboration between reseachers in the field of science education and practicing science teachers.

(2) Centres for research in science education should devote further effort to training science teachers in research methods and then to developing systems to guide and encourage science teachers who wish to undertake research.

(3) Some means should be found to recognize research contributions in science teaching.

(4) Financial support for small-scale research projects in science teaching should be made available. The cost need not be great. Possible sources are: (i) local authorities, (ii) charitable foundations, and (iii) professional institutes. Perhaps the ASE could act as coordinator and adviser.

(5) The existing journals in science education are sufficient to provide outlets for publication of research results. However, there is a need for a mechanism to transfer results and experiences of classroom based research projects. Perhaps the ASE and/or the professional institutes could arrange for regional meetings of science teachers at which the results of their

research would be presented.

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TRANSLATING RESEARCH INTO PRACTICE IN SCIENCE EDUCATION

Introduction

Those of us who lived through the exciting times in science education in the 1950's and '60's have been afraid that such times were gone forever, but here we are with new opportunities to try new ways to bring about the improvement of our profession. In this paper, I would like to first explore where I think we are and to discuss the problems we should try to resolve. Then I would like to propose both short-range and long-range actions that we might consider, providing the appropriate problems have been defined. Within short-range and long-range actions, we will need to address two categories of needs: preservice and inservice. The opportunities are immense, and fortunately many science educators at all levels can build on experiences of the past decades.

Science Education, 1984

This analysis of where we are comes from my perspective as a science educator who has recently returned to a school district after some twenty years in academia, curriculum development, and research and evaluation activities. I have been struck by what I

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perceive to be the presence of two cultures in science education, science teachers and science educators. The science teachers I refer to are elementary, secondary and university professionals who are directly teaching science to students. Science educators include professional educators and scientists who teach teachers to teach science, who conduct research into the teaching and learning of science, or who are concerned with policy issues regarding science, society and technology. Now, I know that this categorization is unusual, but for purposes of this paper I think you will find it has utility.

From my perspective, science teachers need to be discussed in two groups: elementary and secondary though college. Secondary or college science teachers' first reference group for what and how they teach is other science teachers. They ask of their instruction, "Will it meet the expectations of my colleagues?" "Am I preparing my students for the next course?" "Are my standards respectable in the eyes of my colleagues?" (Stake, et al, 1978.) These questions are considered in the context of what Ziman (1980) has termed "valid" science. Valid science is the orientation and subordination of all science education to the production of research scientists. "Validity," Ziman observes, "is the hard core principle of science.... By allowing this principle to dominate every aspect of science education, by subordinating to it the content of every text book, the message of every lesson and lecture, the demands of every laboratory exercise and examination question, we neglect our wider educational responsibilities."

Valid science is coupled with a belief that science is hard to understand and is not understandable by many. This elitist notion is pervasive and provides great stability to current teaching practices. When coupled with the concept of valid science, it makes the concerns of science educators of little interest or concern to science teachers. Is there any need for seeking more effective ways to teach if science is a rigorous, tough, hard to understand field that not everyone can understand anyway? Not if your task as teacher is to offer science to those who want it and sort these students from the common group.

Methods courses don't help much either because they seek to get teachers to "water down" valid science. This view of valid science and of methods courses is especially critical of those science educators who now advocate a new "watering down," teaching _about_ science, diluting it with technology, and introducing the "softest" ideas of all, society and values!

If my analysis is an accurate characterization of the current belief systems of science teachers, it may explain their current professional growth activities: reading materials in science content, attending research seminars and enrolling in science courses. Research in science education is viewed as irrelevant. Indeed, it isn't research at all. This belief system is a "critical barrier," in David Hawkin's terms, to the effective translation of research into practice.

In a striking paradox, we have -- for the first time in my professional life -- research findings that can make critical improvements in the teaching and learning of science. Although it is inappropriate in this paper to review this research extensively, I need to let you know what I am thinking about when I assert a resounding "Yes!" in answer to the question, "Is there any research worth translating?"

First, the field of cognitive science, with its focus on the acquisition of knowledge in science and mathematics, is providing insights that will translate into new teaching and learning opportunities. As this field of research develops, I believe that we will be able to make it possible for a much larger part of the population to understand science than is our current capability. But, is this what science teachers want? If this proposed outcome is a non-problem, why change what we as science teachers do to achieve it? diSessa's (1982) analysis of the persistence of Aristotelian conceptions, the work of Larkin (1982); Lockhead (1981); Johnson, Ahlgren, Blout, and Petit (1981) and of many others in problem solving, points to new ways to structure text material and teaching strategies.

Second, the assessments of children's belief systems about natural phenomena and their relationship to conceptual change have resulted in a restructuring of extant curriculum materials that have resulted in substantive gains in student understanding (Smith and Anderson, 1983). Many other researchers, for example, Nussbaum and Novak (1976), Driver and Easley (1978) and Driver and Erickson (1983), are providing the information required to begin the development of more effective curriculum materials for students, and new methods for science teachers.

A third area of research that is important to translate into practice relates to the nature of scientific knowledge and its relation to science teaching. Most science teachers do not have the conception of science as a way of knowing, with its cannons of evidence and interference, and its limitations, and its method of verification of constructs that become scientific knowledge. This deficit expresses itself most clearly when science teachers are urged to consider issues within disciplines, such as the evolution-creation controversy. The literature is too voluminous to cite, but many biology teachers show that they do not understand the nature of scientific theories and their function within scientific knowledge in order to help students even identify the issues. This serious lack of understanding is even more striking when societal issues are added to the curriculum. Here, teachers must have a firm understanding of the limitations of science and the relations of scientific data to resolving social issues.

Another manifestation of a lack of understanding of the nature of scientific knowledge is the persistent use of the laboratory by science teachers to confirm what the text asserts rather than to utilize the laboratory to help students understand how scientific knowledge is developed.

These three areas of study are only illustrative, but they point to the need for translating research into practice; for they provide sufficient evidence that there is, indeed, research that is worth translating. We must remember, however, that although research on the new curriculum projects of the 1960's showed student gains over traditional science instruction (Weinstein, Boulanger and Walberg 1982; Anderson, 1983), these approaches to science teaching were never even tried by a significant number of science teachers at the precollege level. The positive research outcomes published in the past few years have not led teachers to these courses in terms of materials selection. Similar attempts to change college biology teaching through the Commission on Undergraduate Education in the Biological Sciences (CUEBS) had little impact at the college-university level.

At the elementary level we find teachers with limited knowledge and understanding of science. Their preparation today differs little from the preparation of elementary teachers in 1940 or 1950. Yet the knowledge demands of the society have changed dramatically. With under five percent of adults over twenty-five possessing college degrees in 1940, misunderstandings they passed on to their students went unnoticed. Today, with over seventeen percent of adults over twenty-five years of age with four years of college nationally (Statistical Abstracts of the United States, 1983), and with higher percentages in many suburban communities, such misteaching becomes public and part of the informal evaluation of science teaching by the community.

The third aspect of the current context for science education, 1984, has been more than adequately treated in the numerous national reports on the state of education in the United States. These reports differ significantly from similar reports of the 1950's and early 1960's. They reflect a broad consensus that science education is essential for all young people in our increasingly technological society. This emphasis is refreshing for science educators, who have for some time been advocating the goal of science education for all. (See, for example, Science in General Education, 1938). These reports also reflect a change in emphasis to preparing students for life and for responsible citizenship rather than on the welfare of the individual or inducing social change (Klopfer, 1984).

I have tried to provide a few key characteristics of science teaching, 1984. What I have found is two non-communicating cultures -- science teachers and science educators. Science teachers are concerned with maintaining their standards of "valid" science. From their point of view there are few problems in science teaching except that classes are too large and better equipment and facilities are needed. With less administrative interference in their work and with science courses for students who want to take them, rather than being required to take them, teachers can do their job. They know their subject and how to teach it. Research on teaching and learning science has not helped them before. Provide courses to up-date their understanding of science content, but don't waste their valuable time with "methods."

I also find some science educators whose reference group is science educators. They publish papers to meet the "scholarly demands" of their colleagues. Their status and rewards reside in publication rather than in the impact of their work on science instruction. I think this situation is changing and that more science educators may be seeking ways to translate their research into practice. Establishing credibility with science teachers will be a major problem for these science educators. Strengthening science education research, especially doctoral research, remains a critical problem to be resolved.

Establishing Goals

The premise on which this paper was developed accepted the general goal of infusing research into the practice of science instruction. With the current status established, we can more clearly define goals to consider in order to bring about this desire. Suppose that ten years from now we would like to find the following context for science teaching:

1. Instructional practices at all levels of science education that reflect the best current research findings.

2. Preservice science teacher preparation that incorporates the best of current research in all its activities.

3. Instructional materials grounded in research that outsell other materials and are used in classrooms in preference to other materials.

4. Subject matter inservice programs that treat ends (outcomes, products) and means (methods, processes) as inseparable elements of a single act.

5. Science teachers at all levels who read research papers relevant to their teaching because they find them essential to their effectiveness in the classroom.

6. Science teachers at all levels who consider participation in research activities as a special opportunity to improve their own effectiveness and that of their colleagues.

7. Science education researchers who interact with teachers as a regular part of their research activities.

These suggested goals may sound utopian and need to be criticized and revised, but certainly not ignored. It is time that we engage in both short-range and long-range planning and to formulate plans in ways that will enable us to assess our progress towards their accomplishment. Once goals have been established, plans for their accomplishment can be developed.

Personally, I do not see how we, as a nation, can improve instruction in the sciences without establishing goals. Given the substance of some of the goals outlined above, what actions ought we take toward their accomplishment?

Short-Range Proposals

The most obvious short-range proposal is to develop a commitment to long-range planning. The proposals put forth by the Commission on Precollege Education in Mathematics, Science and Technology to the National Science Board (1983) are a step in the right direction. I do not know if any action will be taken or any commitment made to implement these plans. My feeling is that the suggestions will be ignored by the current administration. I do believe that additional actions are needed to meet the challenges presented in this paper. Specifically, for the translation of research into science instruction, the following ideas might be suggestive of actions that could be taken.

The first task, in my view, is to take steps to demonstrate the importance of research for the improvement of instruction by college level science teachers. They are key figures in determining what is and what is not "research." This might be accomplished in several ways. For example, short courses could be offered by eminent researchers in problem solving, cognitive science, philosophy and history of science and other relevant fields for groups of teachers. This could be done, and I think preferably done, by subject field. It would be well to include secondary science teachers (both middle level and senior high) in such short courses. If this were done well, and by well I mean that college science teachers would begin to incorporate research outcomes into their own instruction, a great barrier to legitimizing science education research would be reduced.

This step should be accompanied by making available journals that publish articles relating instructional research to science teaching at various levels so that such journals become incorporated into the reading priorities of college and secondary science teachers. Encouraging or commissioning articles that apply research to instruction would also be an appropriate activity and one that would strengthen extant journals.

Another step would be the wide dissemination of small curricular packages, as exemplified by the work of Smith and Anderson (1983) with their series of transparencies on light. These packages would model the best research in the three areas previously discussed. Such dissemination would probably be most effective if done as part of carefully worked out short courses or inservice programs.

Science educators at colleges and universities and science supervisors should also be provided with institutes, short courses or seminars to learn of the research being done, its applicability to their tasks, and to show them how they can give support to science teachers as these teachers begin to adopt new strategies for instruction. This suggestion to include science supervisors or other college and school district personnel is a critical one for the process of implementing research findings. Most central office personnel in school districts have found their usual ways of working with science teachers to have little utility in producing changes in secondary science instruction. As already mentioned, science educators at colleges and universities need to be included in this re-education process.

The above suggestion requires that increased support be given to the development of new, small curricular packages that can be incorporated into existing curricula. Such packages need to be developed for use at both the college and precollege levels. I think it would be well to identify specific areas of current courses that science teachers find difficult to teach and that have a research base for change.

The development of alternative packages, whether it be text replacement, laboratory, film, computer software, or other materials, seems to offer a better alternative to curriculum development than whole course revision. This latter approach, tried extensively in the 1960's, required too great a shift for most teachers to adopt. This does not mean that course improvement or development projects should not be done. It means that, in my judgment, the small replacement package offers promise as an effective way to translate research into practice.

The kinds of activities suggested above should be consistent with the goals stated previously, with special attention to ends and means. This modeling of content and method as inseparable is essential to incorporating the research that should affect instruction.

There is one area of research that needs to be added to the short-range planning section. This is added because I find little research going on, but believe that a high need exists for research to be done and then translated into practice. I am speaking of research into testing and evaluation. Instrumentation and measurement are tightly coupled with scientific research, yet science education research includes little in this field. With the advent of computer technology for aiding instruction, it is more likely that we will need to be able to measure student performance more completely and accurately in the future. Support for research in this area is critical.

In this brief discussion of short-range activities I have suggested that college science teachers, public school teachers, science educators, and science supervisors all be included in a concerted effort to translate research findings into practice. I did not mention elementary teachers specifically, but their inclusion in the process might best be accomplished by means of inservice programs conducted by knowledgeable individuals -- science teachers or science educators -- using appropriate, small curriculum packages as described above. Finally, I mentioned the need to support research into testing and evaluation in science education.

Long-Range Planning

Long-range opportunities for the improvement of science instruction through translating research into practice depend, of course, on a vigorous and effective research community. Such a community needs to have long-term opportunities to conduct systematic research that is oriented to improving science instruction for all students. Current research in cognitive science, about children's belief systems, the nature of scientific knowledge, and problem solving are examples of the kinds of research that should be supported.

Support needs to be provided for the development of curriculum packages that are consistent with research findings and that apply these findings to both materials and pedagogy. As this development results in curriculum products, they will need to be examined philosophically to determine their consistency with the nature of scientific knowledge.

There are two other long-range activities that I feel are essential for the improvement of science instruction based on research utilization, and they are tightly coupled. The first is to increase the quality of preservice science education by increasing the undergraduate preparation of elementary and secondary teachers.

We should, as rapidly as feasible, require all teacher education to begin at the graduate level. Elementary teachers need a solid preparation in the liberal arts prior to beginning their professional training. Within this preparation should be ample opportunities to gain experience in public schools. Since the first draft of this paper was written, Education Week (1984) has published a similar recommendation.

It is becoming increasingly evident that teachers need more science background to teach science effectively. Specialization, beginning at grade four, may be the best way to meet these new demands. Certainly, the pattern of preparation now extant is untenable. The program of preparation of elementary teachers is little different now from the 1950's, but the clientele and their parents are a much more informed group than those of the 40's.

The "high tech" civilization the students will be living in differs by orders of magnitude from the 40's, too. Several preparation plans should be developed and tried. One such plan would be to provide a liberal arts undergraduate program with concentration in science and mathematics, science and social sciences, or other combinations. The depth of preparation in the fields of concentration should be adequate to enable elementary teachers to continue their learning in science throughout their careers. The offerings in professional education need to be carefully examined to ensure that they are useful in contributing to the effectiveness of teaching. I am sure that many of the current offerings will not stand up under careful scrutiny.

The current four-year program for the preparation of secondary teachers is even less tenable. The undergraduate program should prepare science teachers in the sciences more deeply and broadly than can now be accomplished. Indeed, I find few science teachers in secondary schools. Most biology teachers know less physics than the seniors in their own schools, for example.

The preparation of both elementary and secondary teachers should be of the quality that would qualify them for a graduate level professional school. Simply put, they should be qualified to continue to learn science and have the background to teach it, given professional study. Their graduate studies in the teaching of science should be based on the best research available and should engage science teaches as well as science educators in their instruction. The preceding suggestion is not new and has been in place at the secondary level in a few states for years. It is a must for the incorporation of a rigorous program of graduate preparation in science teaching.

College science teachers should be held accountable for the understanding of science on the part of candidates for science teacher education at both the elementary and secondary levels. A complete redesign of the preparation at the professional school level will be necessary but is too extensive a problem to be examined here.

A more drastic suggestion must accompany the changes proposed above. The number of schools preparing science teachers should be drastically reduced. Such schools should have a critical mass of research scholars and instructors with the competence to teach the research-based pedagogy that I propose ought to be a part of preservice teacher preparation. These schools should serve as centers for inservice training, and for research and service to teachers of science at all levels.

I think that a long-term plan for the improvement of science teaching needs to include consideration of this proposal. There are too many teacher preparation institutions to provide the competence and quality of instruction that I believe the complex task of science education requires. If we continue to spread our limited resources for teacher preparation over the many institutions currently engaged in the process, we will continue to promote a mediocre response to improved science education.

Summary

I have suggested that a major task in translating research in science teaching into practice is closing the gap between two cultures: the culture of science teachers and of science educators. Science teachers are confronted with the immediate problems of teaching science to students, be they in elementary, secondary or postsecondary institutions. The value these teachers place on research in teaching and learning is extremely low. The status of pedagogy is also low, and these two enterprises are intertwined. Many science teachers claim that the preparation to help them learn how to teach was of little value or was not really necessary. My claim is that this image affects the image of research in science education, making it difficult to get science teachers to attend to new research developments.

My suggestions for closing the gap between science teachers and science educators include efforts at all levels of education. This has not been tried before. Our previous efforts have been directed solely at precollege teachers and their practices. I suggest that we will not be effective if we again ignore the college level. As a major influence group, college teachers of science need to be shown the value of research to their teaching, and, indeed, to incorporate it into their own teaching. College and university science teachers are a major influence on precollege teachers and their attitudes about valid science as well as pedagogy.

Furthermore, exemplary materials for teaching science that incorporate research findings into their very structure need to be developed for teaching science at all levels. I would be remiss here if I did not call attention to the necessity of developing such materials with the role of the teacher clearly in mind. Teacher-free materials have been shown to be useless, or better, nonexistent! Therefore, the materials developed need to be disseminated with appropriate teacher training for their effective use. And these materials must make a difference in outcomes, for both teachers and students.

Finally, I have suggested that in the long run the preparation of science teachers at all levels needs drastic revision, first in the duration of preprofessional education and then in the number and quality of institutions preparing science teachers. These will be difficult suggestions to implement, but they are extremely important for a long-term resolution of the problem of translating research into practice in science teaching and for the improvement of science teaching.

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Discussion: Research in Science Education:

Plenary
Gary Aikenhead, Rapporteur

A deficit in teacher preparation is that teachers are not trained to ask, "Why am I teaching this?"

A positive aspect of university cutbacks is that faculties of education will be encouraged to clean up their programmes. One specific idea is 'distance in-service education' described by Gilbert.

There is a need for specialized training of personnel going into education middle management roles -- head teachers and principals.

Two senses of research were clarified: (1) scientific models; generalizable theory; and (2) teacher research focused on changing the teacher's world.

Not all science education problems need to be attacked using #1. There are smaller scale problems that lend themselves to resolution by an engineering model of research.

Time is the most basic reason for the teachers not becoming involved with research. They value more the investment of the same time in their students.

The usual perspective on research is all wrong. More time, or equal time, should be spent on disseminating the research results to science education state holders than is spent on the original research. Every research proposal ought to include a clear statement of what the researcher will do with the results once they are determined.

A plea was made for a balance between long term research programs and short term research programs. Fear was expressed concerning the possible misunderstanding that the symposium was asking for long term research programs to be replaced by short term teachers-as-researchers projects.

The suggestion that an intermediary ought to exist between the researcher and the teacher (the 'red box' model) gave concern to those who feared that such an arrangement would do away with the direct interaction between the teacher and the researcher -- an interaction of mutual benefit. Both should know about each other's language.

Group I
Jo Piotrowski, Rapporteur

Research in Science Education

A) Topics discussed: Frazer Paper (questions 1-5)

I: How can teachers with some research experience be encouraged to continue?

1. Locate the experienced (dissertations, college lists, etc.)

2. Identify the barriers:

    a. time for teachers is limited
    b. motivation
    c. availability of help:
        - -computers
        - -libraries > -access
        - -strong department heads
        - -career ladders
    d. lack of research skills beyond the basic
    e. lack of large data pool in one school
    f. the jargon may put people off

Question 2: What alternative models for research are there?

1. Call it field studies; make it less rigorous.

2. Provide support services.

3. Allow visiting researchers to affiliate with a school and share the results of research done in that school.

Question 3: Is it desirable for individual teachers to conduct research?

1. If a teacher wants to, it should be encouraged.

2. All teachers should question their own methods.

3. There should be courses offered to deal with research literacy.

4. Teachers should be called together (departmental meetings?) to discuss papers that already report research findings.

5. Guidelines need to be provided to teachers to help them get started on research methods.

Question 4: What topics/skills are most difficult for students?

1. This is an obvious topic that needs researching.

2. From teachers' experience, it appears that the difficulties are:

   a. student's inability to transfer abstract learning to practicality
   b. teacher's (often) inability to do the same
   c. student's difficulty in reasoning, creativity
   d. math fear (students and teachers)
   e. language barriers

Question 5: How easy is it to obtain information about student alternate frameworks?

1. difficult -- often no time to listen to students
2. publish what's available about it
3. do word-association exercises with students

B.) Topics discussed: Robinson paper

1. How can we improve the quality of teacher preparation?

a. Tightening up on teacher prep colleges and courses (perhaps closing some down). ASE has a validation board in U.K. Massachusetts has a new, tighter certification law.

2. There should be more pressure from us upward toward governing bodies.

3. Many teachers don't respect their own teacher preparation courses. Perhaps history and philosophy of education courses should not be given as undergraduate courses but to teachers with five to ten years experience.

4. Perhaps NSTA should get into setting up a NSTA-APPROVED system of evaluating teacher training programs.

5. Elementary teachers need more practical science preparation to increase confidence so that they can influence students positively about science. Perhaps a more experienced science person could be identified in each elementary school to help the rest.

Group II
Dr. C. Harris, Rapporteur

When the group reviewed the questions raised in the two papers, it became more obvious that any Research in Science Education would only be fruitful, supportive and constructive if that research was simply, accurately and succinctly distributed effectively to the teacher "at the chalk-face." Our discussion revolved around this central theme: that results must be disseminated concisely and without too much jargon for the teacher. Canadian bulletins (like Chem 13 News from Toronto) were highly-praised. Similarly, California fliers or "Tips for Teachers," "Quotable Quotes" or "Pearls of Wisdom" all played an invaluable role for the classroom teacher.

It was recognized that the teacher was not lazy but had many other demands on his/her time, energy and enthusiasm -- drama rehearsals, visit planning, worksheet preparation, marking duties, career help, etc. The science teacher does need help and simple guidance in the results of research in science education.

It was proposed that an intermediary (or translator) would fill the gap between research and practice, give straightforward answers to direct implementation of research. We welcomed the stress that Dr. Robinson placed on small packages for it was said that big packages can take many years to come to fruition and publication.

We heard how the role of Science Adviser can change from a befriending situation one day to that of an assessor on the next, and this reinforced our idea for an intermediary/translator who could help the teacher achieve a knowledge of research results and their practice. Some intermediaries do exist, but their number might be increased with support from professional bodies like NSTA/ASE.

Overall, then, the work load increases exponentially for science teachers, educators, advisers, etc., and this situation strongly emphasizes the need for a new "animal" in science education as an intermediary in putting research into practice.

Group III
Alice J. Moses, Rapporteur

Four points for discussion

1. Do we want to involve teachers in research, and if so how and in what way?

2. How to relate research to practice, including dissemination and teacher training?

3. Look at particular questions of Malcolm Frazer's paper (#11,12,13,14).

4. Preparation for science teachers and nature of research in college science.

Discussion and Summary of Question #1.

Rationale for support:

Literacy	1. Yes, for purpose of literacy-increase and improved understanding.
	2. Yes, involvement of teachers as collaborators.
Small scale involvement	a. Role of the teacher as advisor, to critique and assure a "rightness" of the research investigation.
Personal growth	3. Yes, as a practitioner.

Discussion and Summary of Question #2.

Importance of teacher input	1. Those doing research should see that teachers are important to the task of defining problems.
Publications	2. Distillation of published research materials is a dangerous task but has to be done in some cases. Concerns were: removal of essential parts -- leave out qualifiers, being postscriptive, an over-simplification.
Middle agencies	3. Do we need mediators? Research may not be addressed directly to teachers; rather, the information may reach the classrooms through the reaction and interaction of middle agencies such as administrators, supervisors, and/or curriculum designers.
Critical assumption	4. How do we know what is right in curriculum planning if there is no background research information?
Long time strategy	5. Free centers of research to move in and out. Competition among groups to share ideas of research, so that it does not become monolithic.

Discussion of Jim Robinson's suggestion on offering packages of information for school programs

1. Yes, modules may help, but the question remains how materials will be used. What actually survives should be flexible resources with understandable reasons for their uses.

2. Concern for materials that have been developed and then viscerated by publishers because they become too expensive to print or do not fit the competitive market.

Discussion of Questions 11 and 13 in Malcolm Frazer's paper

I. Question 11

a. Issues are complex and multiple, but should have discreet and explicit criteria and should include the following:

1. fundamental
2. give examples
3. for teaching process of science including practical work with inexpensive materials
4. relate to technical applications
5. implications to link science and society (ethical, etc.)
6. can teachers cope with information -- will they be comfortable?

II. Question 13

a. Variety of models:

1. collaborating within, between and among schools, visiting one another
2. working with classroom based labs that should extend over time and with consistency

Group IV
V. Payne, Rapporteur

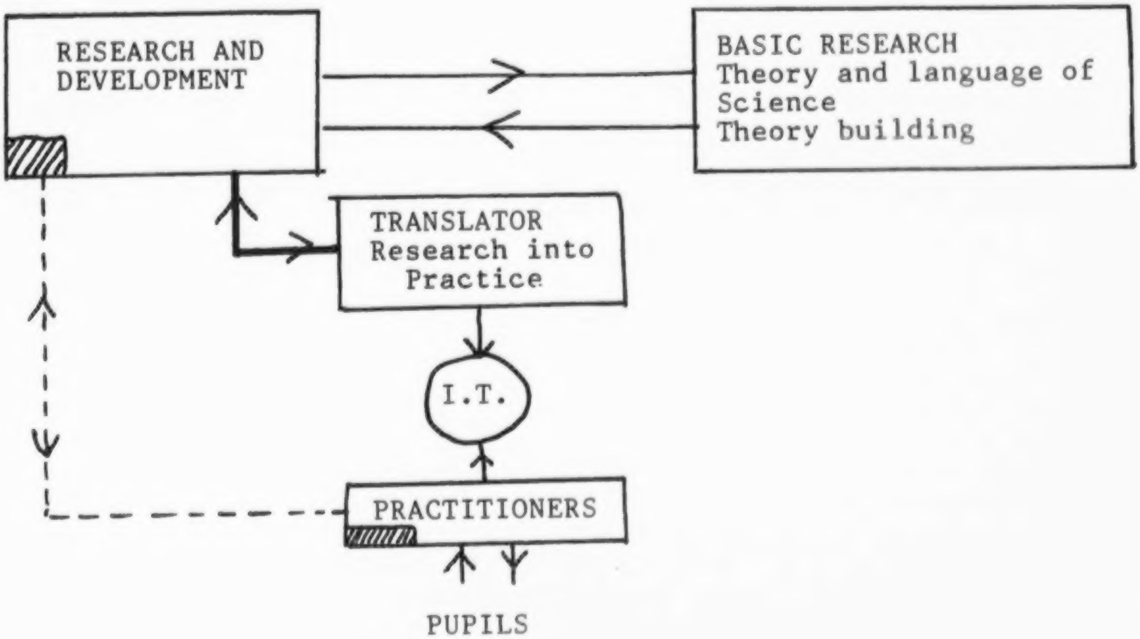
"Research in Science Education -- identifying needs and relating results to practice."

We looked at the statement in Professor Frazer's paper "that all science teachers could, and should, be involved in some way with research related to the teaching and learning of their subject" and questioned the appropriateness of teacher based research. Does the teacher have the time or skills? It was suggested that there is a natural division of labour into two parts. The first part included the basic researchers like neurologists, cognitive researchers, etc., whose results lead to theory building and are not necessarily directly applicable to teaching.

The second group, 'Research and Development,' we saw as being involved in engineering type research -- 'there is a problem, how can we solve it?' This group ranged over a spectrum from practical matters to theoretical concerns, and the teacher/researcher seemed to occupy a position at the practical end.

Clearly, there was a gap between the basic researchers and the practicing teacher, impeding the putting of results of research into practice. We felt the need of a translator and made a comparison with an agricultural agency and medical agency in the U.S. The Co-op Extension Service has agents who help the farmer translate biological and agricultural research into practice in the field and also feedback problems from the farmers to the researchers. (The American Medical Association has a similar agency.) This seemed more accessible and appropriate for teachers rather than the method that subject teachers might consider. For example, scientific researchers turn to publications in their subject area in order to pinpoint areas of research or to develop their own research. We felt that teacher based research seemed to be a way of sensitizing teachers to research findings -- even this might be done more efficiently through the translator.

The diagram below shows how the translator fits into the scheme. The translator, after collating research findings, could effect change in materials and practice and also to change pre- and in-service teacher education -- this latter tied in with James Robinson's paper. Tying in with the theme of 'High Technology Society' it was essential to use the new technique of Information Technology -- not only in the classroom but also in the staff room.



The shaded regions refer to teachers who perhaps teach one day in school and then spend one day in the research department -- attention was drawn to the fact that knowledge gained in this way is gained at a very slow rate whereas full time researchers make faster progress -- this brought us back to questioning yet again the appropriateness of the teacher/researcher.

The translator would be in a position to collect problems from teachers and filter and feed back to the researchers, thus insuring greater efficiency and appropriateness of research work.

Who might fill the super-human role? Possibly someone who is a master-teacher (U.S.A.) or someone moving out of Research and Development.

With regard to some of the areas of research suggested by Prof. Frazer, we felt that there may be a danger of suggesting solutions in search of problems. We suggested an area for research, namely, what do students learn from practical experience; what kind of learning takes place?

PART V

PROVIDING PROFESSIONAL SUPPORT FOR TEACHERS

Papers by:

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Discussion

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THE PROVISION OF PROFESSIONAL SUPPORT FOR SCIENCE TEACHERS

In England and Wales the control of education occurs at two levels -- from central government and from local education authorities; even so, schools have freedom to choose appropriate syllabi and teaching strategies. In Scotland the situation is controlled more centrally.

This paper will concentrate on England and Wales where, in spite of their autonomy, teachers rely heavily on support of a wide and varying nature. Initial training cannot give teachers all they will need throughout their working lives, so this support aims to promote their personal and professional development in general and their specialist subject potential in particular. For instance, a variety of science courses would hope to encourage primary teachers, to help technicians with maintenance of apparatus, to provide discussion sessions for probationers, to update those with some experience, to teach management skills to heads of departments, to inform on safety procedures, and to support innovation, particularly most recently where this will help provide balanced science for all pupils.

The sources of support are:

1. The Department of Education and Science (DES). This body,

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part of the Civil Service, advises the Secretary of State for Education and Science, who makes decisions on educational policy, (1) and it also arranges various courses.

2. The School Curriculum Development Committee and the Secondary Examinations Council (successors to the disbanded Schools Council) that advise on curricular innovation and examination policy. The disbanded body was responsible for the Schools Council Integrated Science Project, (2) an innovative course based largely on the search for patterns. Written for the most able, it has had a relatively low uptake. Many teachers in Britain are suspicious of integrated science and lack confidence in their ability to teach it, and much of the thrust in in-service training needs to aim at alleviating this fear. Nevertheless, SCISP was important, as it formed the basis for other new courses, e.g., Nuffield Science 13-16, (3) which is gaining credence and becoming popular.

The Schools Council was also largely responsible for the moves towards a 16+ examination, which is being considered as a replacement for the separate Ordinary Level General Certificate of Education and the Certificate of Secondary Education; and it set up an Industry Project that aims for industrial understanding by pupils across the curriculum.

3. Industry, including the Department of Industry, that aims to promote understanding and provides financial support and

personnel for such initiatives as Science and Technology Regional Organizations (SATROs). The hope of these organizations is to promote empathy between industry and teachers of science and technology. The lack of understanding that teachers have for the workings of industry is of great concern, and exchanges have been organized to help promote mutual respect for each others' problems. Industry needs to attract the well qualified, but in Britain there is still resistance to this concept. 'Pure' research is frequently the ultimate aim of the most gifted. The tasks undertaken by the SATROs are various, but a coordinator may, for example, suggest suitable industrial projects for students who have put forward some excellent solutions, emphasizing their potential. On the other hand, coordinators could spend much time raising money to ensure the survival of their organization, which highlights one of the great difficulties in British education today -- lack of finance.

4. Higher Education, including the Open University, that provides courses to update and inform teachers of new ideas and skills. The science teaching profession in Britain is very young. Historically, this is due to the rise of comprehensive education. Grammar schools taught the pure sciences, and the large majority of the remaining 80% of the population was given very little science. One of the consequences of reorganization was high recruitment, which resulted in a teaching force with little chance of promotion. These teachers need stimulation to ensure that they maintain a continuing interest for themselves

and for their students. Secondment for courses used to be a relatively simple matter, but with economic difficulties it is now rare. Therefore, part-time courses are gaining in importance. The Open University is easily accessible, as some of its lectures are given on radio and television, and most of the course work is done by correspondence in a candidate's own time. Teachers can also attend universities, polytechnics and colleges of higher education in order to update and learn new techniques, such as teaching primary school science or computer programming.

5. Her Majesty's Inspectors, who go into schools to advise and report on current practice. HMI have written many important documents recently, with the aim of disseminating knowledge gained from visiting schools throughout the country, in the hope of spreading good practice. These have included reports on primary science, on secondary education (with particular reference to science), on topics such as advice on a balanced curriculum, including discussion on important curriculum areas and girls' lack of uptake of physical science. (4) There are frequent meetings between HMI and advisers to ensure a common approach and mutual understanding.

6. Local Authority Science Advisers, who form part of an advisory team whose aim is to act as facilitators and initiators, to boost morale and to participate in and encourage science teachers' activities. The role of the adviser is critical, for with large classes and time spent on preparation and marking, it

is hard for even the most conscientious teacher to benefit from the help currently available. This will be discussed in greater detail later.

7. Professional Associations, e.g., The Institutes of Biology and Physics, The Royal Society of Chemistry and, most important to all science teachers, The Association for Science Education (joint sponsors of this conference). The ASE has recently, in conjunction with the DES and the Schools Council, initiated a five-year Secondary Science Curriculum Review to examine science education for ages eleven through sixteen.

8. Publications, either commercial -- such as The New Scientist and The Times Educational Supplement, which have articles of general interest and are the main source of information on job vacancies -- or professional journals -- such as The School Science Review and Education in Science, both produced by the ASE -- and the publications of other professional associations, which aim to educate and inform. There are also commercially available films and video cassettes, either for hire or on free loan, which help to enliven classroom activities, and the BBC and Independent Broadcasting services have made tremendous contributions to education with programmes on radio and television for all age groups.

9. The Local Education Authorities (LEAs) support Teachers' Centres and Science Centres, which act as venues for meetings and

as a resource centre for apparatus, films, videos and books. The Hertfordshire Science Centre, for instance, has a half-time coordinator. It organizes much in-service training, which is largely initiated by working groups in each of the separate sciences, in integrated science, astronomy and computing. Experts are invited to talk although some of the work is undertaken by local teachers. The Centre also provides a resource lending service for expensive apparatus, and it has a substantial library and photocopying facilities.

10. Throughout the country there are regional computer advisory centres, and some LEAs have educational and library resource centres.

The Role of the Science Adviser

The professional development of teachers needs to take full account of the changing demands of the curriculum. It must meet the needs of the schools and at the same time satisfy the aspirations of teachers for personal and intellectual fulfillment, who must regard it as part of their professional role. Failing school rolls and restraints due to economic recession have severely limited financial resources, with depressing effects on teacher morale. This is particularly unfortunate in this period of rapid technological change with its increasing demands for teachers to adapt and expand their professional skills. The science adviser must help teachers make use of the bewildering but fertile array of sources of support while at the same time providing courses and visiting schools. The main aim must be to alleviate stress and boost confidence.

Science is a dynamic subject, and the more experienced teachers need to be kept up to date, to be informed of curricular innovation, examination developments, safety precautions (changing daily!) and the acquisition and deployment of resources. They may need to talk about their career structure, their subject up-dating courses, their position in the science department, the best apparatus for a particular experiment, or the accident that occurred in a lesson. The approach may be on a one-to-one basis, by circular letter or public meetings. The adviser certainly must be flexible, being a servant not a master, a person who is approachable enough to respond to needs that teachers perceive.

There is a need to help with individual and collective teacher self-evaluation and diagnosis, for a complacent profession is a stagnant one. Classroom visiting is often necessary, particularly in the probationary year, and appraisal of both pupils' and teachers' work is required if a department is to be assessed. This should always, however, be a positive process and not one of criticism -- we all respond to praise. An understanding of the pressures teachers work under is essential, and we should never forget that they make a greater contribution to the life of the school than simply teaching science.

Probationary teachers need continual guidance and help. Small things such as timing of lessons (particularly difficult in a practical subject), teaching of concepts, using simple language, distributing practical equipment and materials, and maintaining safe discipline can all arise out of a formal lesson observation. The chance to talk to someone not directly associated with the school is often valued. Likewise, discussion with other probationers in the same subject discipline can give enormous relief, if only because it leads to the realization that others have similar problems.

The following examples will serve to illustrate how an adviser's involvement can nurture and encourage achievement and a sense of success:

1. A group of teachers with a common interest in integrated science began to meet on a roughly monthly basis. They were encouraged to present General Certificate of Education (GCE) and Certificate of Secondary Education (CSE) syllabi based on Nuffield 13-16 materials (3) in Core Science plus Additional Science, so that all examination students (at least 60% of the population) have access to a single or double science certificate. The examinations involve 50% continuous assessment, so recently a videotape was made to help teachers with the evaluation of the practical work part of this, which many find very stressful. The group is also writing multiple choice items

for topic tests and, as this is a mode 3 examination, will be responsible for producing suitable final examinations. They have been given secretarial help for the administration of these.

A seven evening plus one day course of lectures and workshops was run in which experienced teachers helped newcomers to use these syllabi so that they could tackle unfamiliar ideas more confidently. There is a demand for this to be repeated, which indicates that the examinations are gaining popularity. Schools introducing the course may request a series of visits to assess their success, during which possible further innovation is discussed. This is followed by a written report. Science departments can request talks to encourage them in their tentative acceptance of the new ideas, and there is follow-up at parents' meetings, when the desirability of such courses is discussed. The move towards a programme of science education such as this, which will help young people to develop useful skills, will be welcomed by industrialists, provided they are fully informed.

The working group will continue to meet to develop and refine the scheme of work it has introduced.

2. A group of teachers in one division of the county expressed interest in producing materials for low attainers (roughly 40% of the pupils for whom there is no public examination at present). At an early meeting it was suggested that the scheme be linked

with a CSE modular science course, which was based on published material. (5) Such topics as Food Service, Building Science, Motor Vehicle Science, Pollution, Health and Hygiene, Fibres and Fabrics, Electronics, and Fuels and Energy are relevant to pupils of all abilities and should certainly stimulate this type of student. There was the added advantage of allowing the existence of mixed (exam and non-exam) classes, which is important for small schools. It was decided that there should be input from local industries, in which many of the school leavers would be employed, and because of this a grant of 1000 pounds was made available indirectly through the Department of Industry. This small amount of financial help made possible the employment of a part-time typist and artist and provided money for reprographics. Professional help on the use of suitable language was also available. Teachers' guides listing suitable experiments and support material, pupils' work sheets, and pamphlets on local industries were produced. A certificate of attainment was professionally designed, utilizing a profile report. All are circulated free to schools that request them. Teachers have been released to attend working days when meals and accommodations have been provided. Continuing review of the material occurs, with participating schools being asked to contribute.

This initiative has spread to other parts of the county, and already the material produced has been circulated widely. Now two teachers have part-time secondments with the aim of producing a county certificate for award in mid-1985. Funding from the

Central Government has helped finance this, and much of the work has been submitted to the Secondary Science Curriculum Review. This project demonstrates the catalytic effect of outside assistance in the cooperative work of teachers and has been very fruitful for a small expenditure.

3. The main obstacle to the expansion of science (as opposed to "nature study") into the primary school curriculum is the deep-rooted feeling of inadequacy in primary teachers. Very many are women who feel they were unsuccessful science students or who were offered no effective science instruction in their own school careers. Yet it is in primary schools that the foundations of science ought to be laid by the teaching of elementary scientific concepts and skills and processes of science -- questions, experiments, observations and predictions. This will only be achieved by encouragement and understanding. An after-school talk at a Teachers' Centre was aimed to review types of written materials available to act as starting points for primary school science. The teachers were asked to take away some of the books and work-cards and to report on their suitability at a follow-up meeting after classroom trials. The success of this confidence-boosting exercise is indicated by a number of invitations to visit junior and infant schools to talk about formulating policies and to lead workshops. Hopefully, the science in these schools will gradually improve because it is at the primary level that good practice originates.

Science courses for teachers, which advisers initiate, must start with the needs of children and must aim to produce citizens who are informed and scientifically aware and who can evaluate statements rationally. They must attempt to remedy the serious imbalance between girls and boys in the amount and content of their science education. Otherwise, apart from being unable to remedy the shortage of industrial scientists and engineers, we risk leaving under-developed minds, frightened of the technological world in which they lie and unable to contribute to decision making.

The present thrust is towards a core curriculum in which science would occupy 20% of the time in the fourth and fifth secondary years of all pupils when traditionally an option scheme has operated with the hope that this science should be balanced. The most recent initiatives involve an approach that steps over the traditional boundaries of biology, physics and chemistry, and that includes, for instance, earth science, astronomy, space technology, opportunities to delay specialization and chances for students to design and solve problems in topics that are relevant to them; the schemes should be less overloaded in content, i.e., process orientated. The implementation of such a core curriculum means a substantial need for in-service training of teachers faced with unfamiliar topics, subjects and approaches. This should aim to prevent teachers who find change difficult from retreating behind a curtain of rote learning. High expectations and enthusiasm are essential to motivate pupils to give of their best and to develop their full potential.

To achieve this, all methods of contact are important. All have their particular strengths and weaknesses. Individual discussion is essential so that teachers can feel that their concerns are paramount. The adviser can be a 'sounding board' to whom they can express their innermost professional concerns. This cannot replace group meetings in which teachers can talk to each other, discuss mutual difficulties and exchange ideas and information about sources of teaching aids. The value of in-service training lies not only in formal presentations and discussion groups but in informal chats with peers. Teachers obtain inspiration from the more academic teacher trainers, but they also need the practical advice of an experienced, practicing colleague. The least confident teachers respond most readily to hints and practical tips from those who have no greater prestige than themselves. Advice from our equals has a peculiar value of its own, and it is for this reason that it pays to encourage working groups of teachers from different schools who can exchange ideas and discuss common difficulties. This is an essential part of in-service training.

Thus, the organization of teachers' meetings to work for the Secondary Science Curriculum Review, for instance, can only be seen as beneficial. One such group is interested in the different uptake of science by girls and boys, a problem highlighted this year by the "Women into Science and Engineering" initiative. It is not, however, only the low uptake of physical sciences by girls that is disturbing but the number of boys who leave school with no knowledge of biology. It is a complicated problem, which hardly seems to exist in some schools but which is critical in others. Perhaps change is as much about language, which stimulates the fundamental convictions most men and women have about science, as it is about facilities and career structures. There are certainly plenty of problems with which such a working group can grapple.

Besides this, in-service training is needed on such topics as management skills, laboratory safe practice, teaching non-specialist subjects, using computers, topics for low attainers, good practice in advanced level work, revisions of syllabi and introduction to new examination syllabi. Personal career advancement has been a powerful motivating factor, but not that many teachers have the prospect of remaining in the same school for many years. Advancement must aim to extend personal education and professional competence and improve understanding of educational principles. Much input will also be needed if new methods of assessment, such as profiling and criterion referencing, are to be introduced successfully. The latter has been in use for some time to measure achievement in practical skills, and those converted happily use it. The more nervous need to be convinced that it is easier to motivate pupils when they know precisely the standard they must attain.

There is also work to be done in improving understanding between school departments. Thus, the running of a course on science for home economics teachers can properly be considered a part of a science adviser's duties, providing it is a basis for cooperation. Similarly, it is necessary to give time to help enlighten employers and parents about the complexities of our education system.

Not all in-service training has to be initiated by professionals. Some of the needs can be met by school-based activities, with the selective use of 'outsiders' to act as course consultants. The specific requirements are then perceived by the staff themselves, and they can identify the topics of greatest relevance. The training may start with the evaluation of syllabi from different examination boards and extend to the development of a new course. It may include discussion on pupil management and administration and mixed ability teaching. It should help eliminate rigid role definitions and enable the utilization of each others' skills and self-appraisal. As always, it will benefit from professional interest.

The provision of adequate help increases in importance as the morale of teachers becomes lower. Falling rolls are leading to school closures, resulting in insecurity of positions. Financial cuts mean less to spend on equipment and books and a lower level of technician support, with resultant classroom deficiencies. A young teaching force that entered the profession during the boom years has little chance of promotion. Teacher development is a complex activity. It involves self-improvement and self-assessment, the widening and deepening of subject knowledge (which changes with alarming rapidity) and the improvement of teaching skills. It is concerned with communication with colleagues within the science department and over the whole curriculum as well as within the school and between schools. It must be of great concern as ultimately it involves our most precious resource -- young people.

Points for discussion

1. Attendance at courses is voluntary, and one concern is that many teachers do not utilize the in-service training available. Does the system of credits used in the USA benefit the teachers in any way other than to advance their careers? Do the teachers participate actively and willingly, or do they regard attendance merely as a path to promotion? Would such a credit system be successful in the UK?

2. Bearing in mind financial limitations, what type of in-service training should be emphasized in the next few years? Some suggestions would be:

(a) Courses encompassing balanced science for all abilities.

(b) Writing work sheets that are attractive and demanding and that use the correct level of language. The same applies to examination questions.

(c) The use of micro-computers to enrich science teaching.

(d) The teaching of science with a vocational and technological basis. What about education for leisure in an economy without full employment?

(e) Methods of continuous assessment and the production of records of achievement and profiles.

How effective has criterion referenced competency based assessment been in the USA?

Are these the most important areas of concern for the future?

What other problems might we encounter?

3. How can teachers be given the confidence to adopt initiatives that provide balanced science courses for all pupils? Can we at the same time persuade them to cooperated with teachers from different curriculum areas? In how many of our secondary teachers is there an unrecognized feeling of inadequacy preventing their cooperation with science departments and

inhibiting the fulfillment of a balanced curriculum?

What methods can be used to persuade the authorities in higher education, and industrial employers, to accept more broad-minded approaches? Without this cooperation, progress towards producing a scientifically literate society will be unacceptably slow.

4. What ways are there to prop up teacher morale? Unless teachers feel there is a real hope of producing better equipped citizens in the future and that there are real job opportunities for their students, will it be possible to continue to attract good scientists into the profession?

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AN INSIDE LOOK AT PROFESSIONAL SUPPORT AN ESSENTIAL FACTOR IN SCHOOL-BASED CHANGE

Introduction

The principal is generally recognized as the key director in stimulating and effecting successful local school change efforts. What about the professional support mechanisms of central office personnel, university faculty, community resources or national diffusion project trainers? Do they make a difference? The results from the Study of Dissemination Efforts Supporting School Improvement (Crandall and Associates, 1982) suggest a definite "yes." Analysis of the findings indicate that it is a multi-dimensional team including principals, school staffs, central office facilitators and consultants outside the district that constitute the constellation of players who collectively effect change. Each has a unique role.

This is consistent with the experience from the past several years of the science department in the Jefferson County (Colorado) School District. The Division of Instructional Services, of which the science department is a part, is responsible for creating curriculum as well as being an active participant with the local principals in its implementation,

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maintenance and support in the classrooms where curriculum comes alive.

The scope of this dual purpose increases significantly when the setting becomes as large as the Jefferson County school system, which has approximately 3,500 teachers and 75,000 students. The Jefferson County School District was formed in 1951 when 39 separate, small and independent school districts were unified as the first reorganized district in Colorado. The county is large (783 square miles), running north-south beginning at the western boundary of the city of Denver and extending into the mountains on the west. The total population of the county is 387,000 with a school population of 76,529 distributed racially as follows:

American Indian or Alaskan Native	383	0.5%
Asian or Pacific Islander	1,399	1.8%
Black, not of Hispanic origin	481	0.6%
White, not of Hispanic origin	70,607	92.3%
Hispanic	3,659	4.8%

The county is generally a middle-class, bedroom community with two major industries, the Martin-Marietta Missile Aerospace Corporation and Coors Brewery. The population is declining slightly after having peaked at almost 81,000 six years ago. The center of the county is declining in population while the north and south ends continue to grow, and new schools are being constructed in both of those areas.

For many years the Board of Education has adopted well-defined, tested and evaluated curriculum projects for use in all district schools. The policy of district-wide use of programs is reinforced by a time allotment policy that designates how much instruction time will be devoted to each subject at the elementary level. An extensive Staff Development Academy was established seven years ago to support the training of teachers in the use of new programs. This collection of policies and practices has been an important factor in achieving the institutionalization (Miles, 1983) of most district programs.

How does a central office science team effect curriculum changes in the front lines of Jefferson County Schools? The science department's position, reinforced by the DESSI Study (Crandall and Associates, 1982), is that change must be done collaboratively, utilizing and coordinating the talents of people from all sectors. Central office personnel function as "curriculum developers" and "implementation facilitators." A sound program that is not used becomes an extinct species; a magnificent idea without nurturing and support soon falls by the wayside and dies. Why spend taxpayers' dollars to develop curriculum if there is no guarantee that it will have an impact on students?

What are the interventions and collaborations involved in promoting curriculum implementation and actual use? This paper will describe specific activities of the science department staff including: (1) collaboration with a university research and development center, which provided a conceptual framework for change, (2) implementation of the Revised Elementary Science Program, and (3) initiation of an ongoing Instructional Improvement Process to see that the program is well implemented.

Collaboration Between a Research Center and School District

People effect change. New curricula are not developed, delivered to schools, and immediately incorporated into the daily routine of teachers. Genuine change cannot be legislated or decreed nor can it occur overnight starting from the "grass roots" (Berman, McLaughlin, et al., 1975). Too many innovations have been unsuccessful because people's needs have been overlooked and unattended.

A Model for Change

How does one manage the change process so that people are motivated to adopt a new program? The Jefferson County science department was struggling with this question prior to implementing the Revised Elementary Science Program in 1976. After three years of development, which included a pilot study field test and careful review by citizen and administration groups, the curriculum was ready to be set in place. Concurrently, researchers at the University of Texas Research and Development Center for Teacher Education were in the process of developing a model of change called the Concerns-Based Adoption Model (CBAM) (Hall, Wallace, Dossett, 1973), which provided a clear and systematic means of describing how people move through the change process. When these two groups met in 1976, a three-year collaboration began wherein researchers and practitioners examined the usefulness of this model in the implementation of the revised curriculum (Loucks, Pratt, 1979).

One dimension of the concerns-based approach is the Stages of Concern (SoC) or the various motivations, perceptions, attitudes and feelings people experience each time an innovation is adopted (Figure 1). The Levels of Use (LoU) is another dimension of the model which describes the levels of behavior of individuals as they approach and move through the use of an innovation (Hall, Loucks, Rutherford, Newlove, 1975).

Initially, "concerns" are informational (SoC1) and personal (SoC2) in nature. For example, teachers want to know what the new program is and how it will effect their routine. When actual delivery of the program begins, daily management (SoC3) concerns, which include juggling schedules, preparing materials and organizing the classroom, are paramount. Once a comfort level is achieved, individuals can look beyond their own needs and focus on improving instruction so student learning can be increased. At this point the emphasis is on *consequence* (SoC4), and teachers are concerned about how the program is affecting learners and how to increase its impact. While *collaboration* (SoC5) concerns are generally limited for most people, they tend to surface when teachers actively seek each other out and discuss how they can be more effective with the new program. Finally, *refocusing* (SoC6) occurs when the individual begins to consider another program that might have even more positive impact on students than the present one.

Figure 1

Stages of Concern

States of Concern	Indicators of Concern
0 Awareness	I am not concerned about it (the innovation).
1 Informational	I would like to know more about it.
2 Personal	How will using it affect me?
3 Management	I seem to be spending all my time getting material ready.
4 Consequence	How is my use affecting students?

5 Collaboration	I am concerned about relating what I am doing with what other teachers are doing.
6 Refocusing	I have some ideas about something that would work even better.

There are four underlying assumptions about change in the concerns-based model:

1. Change is a process not an event (two to five years).
2. Change is accomplished by individuals, not institutions.
3. Change is a highly personal experience.
4. Change entails developmental growth in both feelings and skills each time a new program is introduced.

Because the model is people-oriented, systematic and usable, it has become the basis for all change efforts involving science curricula in Jefferson County Schools.

Implementation of a New Program Using a Concerns-Based Approach

The Concerns-Based Adoption Model sounded interesting, but how would it translate into reality? A description of the implementation process for the Revised Elementary Science Program illustrated how it occurred in Jefferson County.

A New Program Requires Additional Skills

The Board of Education approved full-scale implementation of the program in February 1976 and allocated thousands of dollars so elementary children could receive a hands-on, inquiry-oriented science program that did not include the use of a textbook (Hrebar, Pratt, 1982). However, the program demanded teacher-facilitators who could structure concrete exploration, develop concepts through questioning techniques and encourage application. Experience indicated that teachers were not familiar with this type of teaching and were apprehensive in general about teaching science. Program failure would be almost guaranteed if these "concerns" were not addressed.

It was at this point that an extensive inservice program based on the Concerns-Based Adoption Model was designed in collaboration with the University of Texas R and D Center for Teacher Education (Pratt, Metzdorf, Melle, Loucks, 1980). Recognizing that people take time to change, a concentrated inservice effort for teachers involving three inservice days, two weeks apart at the beginning of the school year, was abandoned. Instead, a year-long implementation plan involving approximately one-third of the 80 elementary schools at any one time was selected. The inservice plan for each group of schools consisted of pre-inservice, inservice and "comfort and caring" visitation.

Preparing Staffs for Change

The pre-inservice session was designed to generate awareness, to provide information and to address personal concerns about the program (SoC 0, 1, and 2). This was accomplished in small group settings where staffs from two buildings gathered in one of their schools to meet with science department staff. An upbeat, fast-paced slide/tape presentation was shown to create a feel for and knowledge about the program. Inservice plans were shared, suggested teaching schedules were reviewed and teachers' guides were distributed. An informal and relaxed atmosphere was consciously structured so teachers would ask questions.

Providing Inservice

The strategies of the inservice program shifted to management concerns (SoC3) two months later during the first full day release workshop. During this session inservice leaders who had already taught the new curriculum modeled classroom management and organizational techniques while involving the participants in actual hands-on experiences. To accommodate any teacher who had consequence concerns (SoC4), self-paced modules were provided, including use of the out-of-doors, development of questioning techniques, encouragement of student-to-student interaction and the application of Piaget's research to classroom practice.

The second and third sessions were scheduled approximately three and six months after the first one. This allowed teachers time to teach the units presented on the first day before receiving instructions on the next one. Time was provided at each session to deal with any problems encountered by the participants. In addition, a great deal of sharing occurred informally during the breaks, lunch and at the end of the day.

On-site Support

Between sessions, science department staff members engaged in "comfort and caring" visits in the schools with teachers to troubleshoot problem areas. During lunch or planning time, in the teachers' lounge or in the classroom, issues could be informally addressed, questions asked, suggestions offered, alternatives recommended and problems solved. This was a time for trust and confidence building while again focusing on the concerns teachers were experiencing and the skills needed to deliver the program.

Administrator Concerns Addressed

Teachers' concerns were not the only ones dealt with during the intensive, district-wide implementation effort. Prior to any of the pre-inservice, a principals' half-day inservice was conducted in which principals received information about the program (SoC1) and what it meant for them (SoC2) as well as cost, equipment and material requirements, ordering procedures, storage systems, staff inservicing and scheduling plans (SoC3). Strategies to support their staff throughout the change were also shared (SoC4 and 5).

Effect of the Implementation Process

"Did it work?" "Were teachers actually using the new program in their classrooms?" Analysis of the data indicated an "affirmative" (Loucks, Hall, 1979; Loucks, Melle, 1980). Science was being taught by teachers who previously did not have the interest or skills to deliver a hands-on, inquiry-oriented program. The personal and management concerns of teachers had been addressed to a sufficient degree that implementation and actual classroom use was attained. While student achievement was not formally measured, the program developers maintained that increasing the extent to which the program was implemented would improve the amount and quality of science instruction and subsequent achievement for students. Recent meta-analyses show clearly that students in hands-on activity-oriented programs achieved more, liked science more and improved their skills more than did students in traditional textbook-based classrooms (Shymansky, Kyle, Alport, 1982).

Program Maintenance

Professional support did not end when all teachers had been inserviced by June 1978. With the cooperation of the District Staff Development Academy, the three-day inservices are offered annually for all new teachers and those who have changed grade level. They are delivered by enthusiastic, experienced classroom teachers who actively engage the participants in guide activities, model management and organizational strategies, discuss unit content, and problem solve concerns. The science department staff also maintains its "comfort and caring" activities in a systematic fashion.

An Instructional Improvement Process to Maintain a Quality Program

With the science program fully implemented and consistently maintained, was there a mechanism for school staffs to focus on their unique implementation? Only 25% of the teachers had reached consequence concerns at the end of the three implementation phases. Could a process be designed that would primarily emphasize the consequences of the teaching strategies and the resulting effect on student learnings?

Since no well-defined model was readily available for this purpose, the science department developed the Instructional Improvement Process (IIP) as an intervention to improve the implementation of the program in the individual schools (Melle, Pratt, 1981). Based on the Concerns-Based Adoption Model and "coaching strategies" (Joyce and Showers, 1983), which incorporate information, practice and feedback for teachers, the Instructional Improvement Process involves an interplay among principal, school staff, and science department staff to improve the implementation of the science program. All of these players analyze the delivery of the curriculum in terms of Key Features (Figure 2), which describe what a well implemented program looks like in each school. There are several components involved in this rather complex and time consuming, although effective, process (Figure 3). They include establishing commitment, training of principals for data collection, communicating the process to teachers, allowing time for practice, collecting data, and summarizing, sharing data and establishing an improvement plan.

Figure 2

Key Features of the Elementary Science Program

Program Key Features over which the principal and the teacher both have a major responsibility for influencing implementation in the building and classroom.

1. Provisions are made for appropriate instruction time, class size, and inservice.

2. Elementary science facilities are adequate and conducive to instruction.

3. Financial support is adequate and appropriate for the elementary science program.

4. The elementary science guides are the basis of the curriculum: re: objectives, activities, seasonal considerations and assessment.

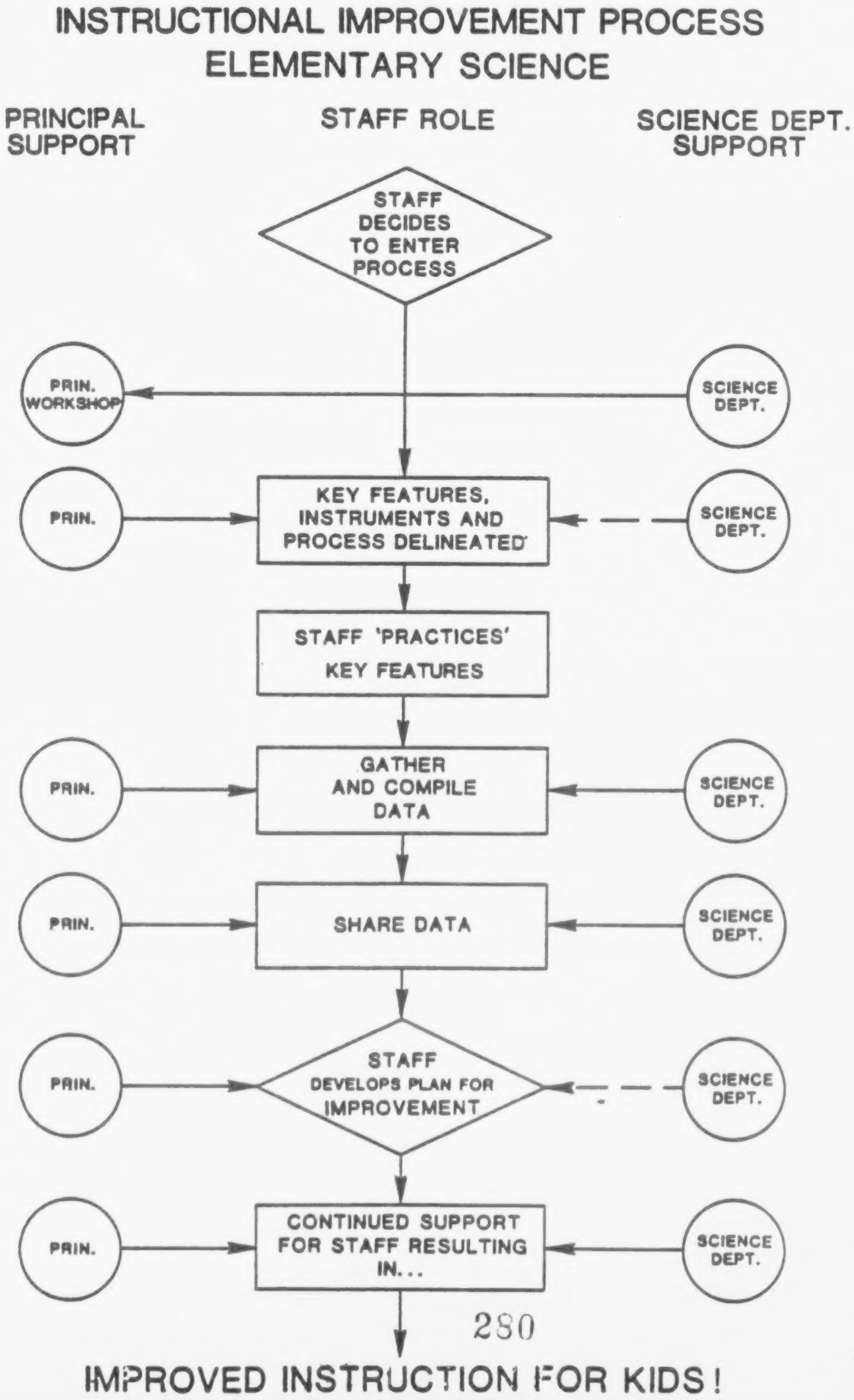
Program Key Features over which the teacher has the major influence for implementation and potential impact for student learning in the classroom.

5. Instructional practices implement the elementary science program.

6. Management practices facilitate the instructional program.

7. Instruction follows the stages of the learning cycle.

Figure 3
Components of the Instructional Improvement Process


INSTRUCTIONAL IMPROVEMENT PROCESS
ELEMENTARY SCIENCE
PRINCIPAL SUPPORT
STAFF ROLE
SCIENCE DEPT. SUPPORT
STAFF DECIDES TO ENTER PROCESS
PRIN. WORKSHOP
SCIENCE DEPT.
PRIN.
KEY FEATURES, INSTRUMENTS AND PROCESS DELINEATED
SCIENCE DEPT.
STAFF 'PRACTICES' KEY FEATURES
PRIN.
GATHER AND COMPILE DATA
SCIENCE DEPT.
PRIN.
SHARE DATA
SCIENCE DEPT.
PRIN.
STAFF DEVELOPS PLAN FOR IMPROVEMENT
SCIENCE DEPT.
PRIN.
CONTINUED SUPPORT FOR STAFF RESULTING IN...
SCIENCE DEPT.
IMPROVED INSTRUCTION FOR KIDS!

Establishing Commitment

Initially principals are invited to participate in the process. If the principal is interested, the science department and principal present the model to the school staff. The intent at this stage is to present an overview of the process and to emphasize the positive and beneficial results for instruction. It must be noted that the principal is an instrumental motivator in encouraging his staff to commit to one year of instructional improvement. The basic assumption is, "we're implementing the program well, and together we can make it even better for students."

Principal Training for Data Collection

When a decision has been made by the principal and staff to become involved in the process, the principals and assistant principals of the participating schools and the IIP cadre teachers attend a two-day workshop conducted by the science department staff. The IIP cadre consists of two classroom teachers who are provided twenty half-days of substitute time. This enables the science department to increase the number of schools in the Instructional Improvement Process without increasing permanent staff. During this workshop the seven Key Features, which delineate essential program elements that can be observed and/or measured, are presented. The accompanying Key

Feature Indicators (Figure 4) designate the level of implementation along a continuum from "outside the intended program" to "best practice." The latter describes what ideally "can be." Instructional improvement is viewed as movement towards "best practice."

Following this introduction, strategies to help teachers move toward "best practice" are explained and discussed. Data-gathering tools used to monitor the Key Features are shared, and data collection practice is provided through simulation and actual classroom observation.

Communicating the Process to Teachers

The principal, IIP cadre teachers and science department staff conduct a meeting at the school to share the improvement process with the school staff. The staff gains an understanding of how the Key Features relate to their classroom practice and to their individual time commitment. While the principal will devote thirty to forty hours to the process, each science teacher will spend five to ten hours in staff meetings, informal "comfort and caring" visits, specially designed workshops for identified needs, and post observation "coaching" sessions. Teachers are then asked to conduct a personal self-assessment, which determines how they feel they are doing in relation to the Key Features and targets areas for assistance that may be provided on a one-to-one or small group basis. The atmosphere during the staff meeting is informal, allowing questions to be raised and active interaction to occur.

Allowing Time for Practice

Because change takes time, a two to three month "practice period" is built in for teachers to adapt, modify and refine their current practices as well as to develop rapport and trust with the IIP cadre teachers and science department staff who will each observe one full science class. The practice period provides time for dialogue, suggestions on management and organization, demonstrations, alternative teaching strategies and mini-workshops on discussion techniques, wait time, neutral reward or cooperative learning. Cadre teachers and the science department staff spend half-days in schools addressing identified needs.

The IIP cadre teachers add a dimension of credibility that the science department staff cannot provide (Crandall, 1983). There is a day-to-day classroom reality shared by the cadre teachers and the school staff that builds a teacher-to-teacher collegial bond. Because cadre teachers are viewed by their peers as credible role models, they constitute a significant factor in the improvement process.

Figure 4

Sample of Key Features and Key Feature Indicators

4 THE ELEMENTARY SCIENCE GUIDES ARE THE BASIS OF THE CURRICULUM: RE: OBJECTIVES, ACTIVITIES, SEASONAL CONSIDERATIONS AND ASSESSMENT.

	OUTSIDE INTENDED PROGRAM 1	WITHIN PROGRAM 2	BEST PRACTICE 3
4a.	During the school year, less than 85% of the objectives and required activities are taught. Some required grade level units may not be taught. Exceptional students do not receive the science curriculum.	During the school year, 85% of the objectives and 85% of the required activities are taught for every required grade level unit. Exceptional students receive the science curriculum according to their needs and abilities.	During the school year, all objectives and 90% of the required activities are taught for every required grade level unit. At the end of some objectives optional activities are used to extend the unit with some students.
4b.	The teacher cannot: ●relate what objective is being studied. ●how the activity pertains to accomplishing the objective.	The teacher can: ●relate what objective is being studied and how the activity pertains to accomplishing the objective.	The teacher can: ●relate what objective is being studied and how the activity pertains to accomplishing the objective. ●relate what objectives and activities preceded and will succeed the objective being taught.
4c.	The outdoor classroom is used for activities when specified in the guide less than 85% of the time. Guidelines, as found in the preface on page xv of each guide, are not followed. The outdoor classroom is not conducive to the spirit of the science program as evidenced by: ●domination of the teacher in lecturing, labeling, giving directions or controlling group and/or ●focus on worksheet completion rather than on direct experience.	The outdoor classroom is used for activities when specified in the guide 85% of the time. Guidelines, as found on page xv in the preface of each guide, are followed most of the time. These include: ●pre-planning ●preparing the class ●field recommendations	The outdoor classroom is always used when specified for activities as part of a unit. Guidelines, as found in the preface on page xv of each guide, are followed. These include: ●pre-planning ●preparing the class ●field recommendations ●follow-up The outdoor classroom is used in the spirit of the science program, i.e., learning from direct experiences. The experiences, not the leader, teach

Collecting Data

After a positive working relationship has been established, the next component in the improvement process involves data collection based on the Key Features. The principal conducts a focused interview with each teacher. The interview not only provides an opportunity to collect data but, perhaps more importantly, allows time for the principal and teacher to discuss instruction within a specific curriculum area. How frequently would this occur if it were not structured in some concrete fashion?

The principal, IIP cadre teacher and science department staff member also make a classroom observation followed by feedback for each teacher involved in teaching science. The critical factor for instructional improvement is not necessarily the actual observation but rather the "coaching" interchange (Joyce, Showers, 1983) after the classroom observation. Because a trusting relationship has been consciously developed during the practice time, coaching sessions result in exchanging reflections, checking perceptions, sharing frustrations and successes, providing technical information about the lessons, suggesting alternatives and mutually working through problem areas. Teaching can be an isolated profession. Coaching strategies increase interpersonal contact and support among professionals while at the same time improving instructional

Figure 5

Sample Composite School Profile
For All Science Teachers Grades 3, 4, 5, 6

ELEMENTARY SCIENCE PROGRAM KEY FEATURES

JANE DOE ELEMENTARY IMPLEMENTATION BY CLASS		OUTSIDE INTENDED PROGRAM 1	WITHIN PROGRAM 2	BEST PRACTICE 3
1. Time, Class Size, Inservice	1a. Time Allotment		********	[redacted]
	1b. Class Size		********	
	1c. Inservice		*******	*
2. Facilities	2a. Instructional Space			********
	2b. Furnishings			********
	2c. Site Selection		********	[redacted]
3. Financial Support	3a. Material Availability			********
	3b. Budget		********	
4. Program Delivery	4a. Objectives Taught			********
	4b. Teacher Knows Objective			********
	4c. Outdoor Classroom		*	*******
	4d. Assessment		*******	[redacted]
	4e. Record Keeping		***	****
	4f. Long-range Planning			********
	4g. Short-range Planning			********
	4h. Daily Plans		*****	***
5. Instructional Practices	5a. Objectives Shared		*	*******
	5b. Use of Class Time		**	******
	5c. Cooperative Learning		*****	***
	5d. Interactions		****	****
	5e. Basic Skills			*******
6. Management Practices	6a. Classroom Environment		********	[redacted]
	6b. Retrieval System		*	*******
	6c. Safety		********	[redacted]
7. Learning Cycle	7a. Learning Cycle		*	*******

techniques.

Summarizing, Sharing Data and Establishing an Improvement Plan

Data from the observations and interviews are summarized jointly by the principal, IIP cadre teachers and science department staff. An individual for each teacher and a composite school profile (Figure 5) are developed. In a one-on-one conference, the principal shares the individual profile with each teacher, and together they target specific Key Features on which to concentrate in the future. Everyone involved in the process then meets as a group to analyze the composite school profile. With the principal's leadership, the staff develops an improvement plan for the following school year. The plan can include, but is not limited to, the following activities:

- workshop(s) to develop further refinement of one or several Key Features for all science teachers
- mini-workshop(s) for a small group of science teachers
- one-on-one assistance
- continued, periodic "comfort and caring" visits

A Model Transferable To Other Curricula Areas

The Key Feature of the science program has served as the organizer for all the interaction among players involved in a coordinated, systematic process to increase program implementation and improve instruction. Data collected for the past three years indicates a definite movement towards "best practice."

One unintended outcome was that principals and central administrators saw the application of the process in other content areas. As a result of this interest, IIP was studied extensively by the administration and after some modification, adopted as a district-wide policy by the board of education.

Future Directions: Commitment to Curriculum Development and Use

What are the implications? Can excellent programs endure without a well orchestrated effort to ensure their survival? Possibly, but not probably. The evidence is mounting that full-scale assistance is necessary if teachers are going to use new quality programs (Yager, 1984). Without intervention, excellent programs will gather dust on the shelves of curriculum developers. Central office support must continue to be viewed as more than curriculum development. Boards of Education must foster the institutionalization of new curricula by encouraging development of sound programs, providing sanction through formal adoption and supporting long term implementation activities. Central office staff can have an essential role in facilitating the transition to classroom use through cooperation with principals and school staffs to make change a reality.

The choice remains with each school district and its philosophical perspective on curriculum development and implementation. Decisions on these issues will determine whether or not songs will be heard.

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Discussion: Professional Support for Science Teachers

Plenary

Gary Appel, Rapporteur

Cindy was questioned regarding the changes that would be necessitated in the event of dramatic resource cutbacks in her support and implementation program. She replied that (1) they would work with fewer schools, and (2) she referred to the teacher "cadie" system described in the paper.

The major point in the discussion was that we should take care not to ignore the need to have secondary science teachers stay up-to-date in their chosen field. We need to keep content and process in balance. A strong foundation in a subject area is one of the components in the building of a successful teacher.

At the same time it was recognized that science teachers often identify first as scientists, e.g., chemists or biologists, and second as teachers. This self-definition is limiting and needs to be changed.

Group I

Richard Hull, Rapporteur

1. It was felt that professional support was needed at the various levels of policy working for science education. The public and politicians need to be informed about the aims, intentions, and needs of science education. Our two associations have a vital role to play in this aspect of professional support. They need to be active and to make use of the media in putting the issues before the public.

2. There was general agreement that at the elementary school level the requirements on each side of the Atlantic were similar. Teachers needed professional support at all levels

--to motivate and sensitize them.
--to inform them about science, both process and content.
--to improve their knowledge of teaching.

Experience suggested that teachers need materials both for themselves and for their pupils. The group agreed that support from the principal/head-teacher and from the district or area were both of great importance. Both associations have published material available to help to define the principal's role.

3. At the secondary/high school level we were struck by the differences in roles. Support services both within schools and within areas may be better developed in the UK than in the US. In the UK, the role of the 'head of science' in school is a vital

one. The ASE has done a lot of work on this topic.

GroupII
Alan Winfield, Rapporteur

What can science supervisors/advisers do to be more effective?

We felt there was a need to overcome misunderstandings concerning the supervisor's role. Supervisors need to explain their support role very clearly and to be sensitive to the needs of teachers. They should be people in whom teachers have confidence, with whom they can interact, and by whom they can be stimulated. We felt that experts who made only brief visits to schools were not very effective in stimulating curriculum development.

The function of Teachers' centres in the United Kingdom was discussed. These centres have Wardens who organize inservice education at the request of teachers and advisors. This was felt to be a very cost effective way of providing support and stimulation for teachers.

We agreed on the need for an on-location science adviser who could support, stimulate, and encourage curriculum development. In the U.K. this role was seen to be played by the Head of the Science Department.

The group addressed itself to the problem of involving more teachers in curriculum development and Inservice Education. We felt that if updating teachers was considered worthwhile, then release ought to be provided. The best model for curriculum development was seen to be teachers teaching teachers. The view was generally held that current courses for teachers provide too much subject content and not enough methodology for teaching science.

We thought the following recommendations ought to go out from ASE/NSTA:

(1) All teachers should have to attend some form of inservice training at least every three years.

(2) NSTA/ASE should recommend and validate such courses.

We turned to the need for disseminating examples of good practice among science teachers in order to observe and discuss practice with other teachers in other schools. Newsletters should contain articles on learning style and real classroom ideas as well as subject content. We thought that ASE/NSTA should make a recommendation for teacher release to visit other schools and that this release could be effected by supervisors/advisers substituting for the teacher.

It was felt that trainers, advisers, researchers, and teachers could mutually support one another more if they occasionally exchanged their roles. One member of our group was a classroom teacher released for a maximum of four years to encourage and support curriculum development. We felt this was a good model to follow.

Group III
Glen Aikenhead, Rapporteur

Taking the presentations as U.S. and U.K. approaches to inservice education, the groups recognized that one can find instances of each approach in the other country. The artificial framework, U.S. versus U.K., based on the two presentations, did, however, allow us to analyze the inservice support in both countries.

The differences between the Jefferson County (J.C.) model and the English approach include:

(a) outside experts using personnel management models appropriately applied; versus an outsider gaining the teacher's meaning of his or her work in the classroom and then the outsider helping the teacher appropriately.

(b) helping a teacher to implement a program of which the teacher is unaware; versus helping teachers at their teaching, which has caused low morale.

(c) in its explicit specifications, the JC model does not specify how to deal with failure in the process; versus the tacit nature of the English approach, which leaves the outsider to deal with failure on his or her own.

(d) one proceeds step by step in a linearly organized pathway; versus a holistic view to change with the teachers establishing their pathway.

(e) the JC model motivates teachers toward inservice; versus the English approach, which draws upon the naturally occurring teacher motivation. This approach creates a critical barrier to inservice training and is a major problem in both countries.

(f) the U.S. teachers have little technician support (except for some imaginative student-technical projects) versus English teachers, who receive technician support.

The similarities between the JC and English models were noted and thoroughly discussed:

(a) both support teachers from a positive perspective

(b) both require a school-based leadership system that supports the teacher after the outsider leaves (e.g., school tutors, master teachers, administration support, teacher support network). On this point it was concluded that the personalities of participants are far more important than systems.

Of utmost importance is the goal to increase a teacher's confidence in his or her teaching. A critical barrier to helping teachers is breaking into the privacy of the classroom by the school-based support personnel listed above. The extent to which a teacher freely allows others into the privacy of his or her classroom is the extent to which others can be truly helpful.

A different series of issues was discussed within the framework of professional development, starting with preservice instruction at teacher education centres or faculties and extending into inservice work with employed teachers. There is an arbitrary cut-off between preservice and inservice work by institutions. In reality, there is a continuous development, which is characterized by different needs at different times along the continuum. (E.g., first year, survival skills; regression towards teacher-centered, highly structured practices; and depression in which a teacher feels betrayed by the teacher education institution for not adequately preparing him or her, and feels mistreated by the school.) Teacher support may be more critical on some occasions.

Group IV
John K. Gilbert, Rapporteur

Provident Professional Support for Teachers

The Group felt that the structure, form and time of professional support for teachers would be influenced by the framework for salary progression. Although no substantive discussion took place on the desirable strength of their influence, a most informative exchange ensued on the current situations in both countries. Byzantine theology was thought to be relatively straightforward compared with:

i. The U.S. scene:

Here salary (very broadly speaking) is governed by a combination of 'years of teaching experience' and 'credit rating,' which is closely related to the use of inservice courses of specific durations. Although this approval was seen to head directly to teacher participation in inservice work, a number of them work, and a number of shortcomings were noted.

a. as attendance was the primary object, there was no strong incentive, beyond the need to attract customers, for higher education teachers to provide material of direct relevance to school teaching.

b. although some approval for credit-worthiness is reviewed, teachers are able to take courses that have no conceivable worth to their everyday work.

c. as contracts are typically 9-1/2 months a year, and teachers often take vacation jobs. This means that that teacher may become over-stretched.

ii. The U.K. scene:

Here classroom teachers drew nationally determined salaries on one of a few, partially overlapping scales. Deputy Head-9, Head-teachers receive salaries from a total of 28 overlapping scales. Contracts assume whole-year commitment with a stipulated 13 weeks vacation. From the point of view of professional support, only disadvantages could be seen.

a. promotion, for classroom teachers, between scales only takes place when a new job, often in a new school, is acquired. Thus, inservice participation activities are not directly rewarded. Salary, for Deputy Head-9 head-teachers, is governed by the number and age of the pupils. Thus, heads are much concerned to retain pupils against demographic trends: this can lead them to encourage inservice work.

b. declining teacher mobility is leading to a drop in inservice participation. The group identified a number of types of inservice work.

- a. 'on-service': the random interaction in the course of everyday work.
- b. 'school-based': peer teaching within a school
- c. 'school-focused': the use of external speakers to support peer-organized activities.
- d. 'inservice education and training': teachers and teacher education working together on common problems. This is often organized by 'chance agents' of the UK 'Science Adviser'
- e. 'self-directed personal professional development': an individual teacher actively seeks out information as a matter of professional interest. The supportive role of the Departmental Chairperson was recognized.

Any comprehensive scheme would include all types, but would also be to encourage (e).

The Group identified two main tasks for all inservice activities.

1. Educational matter. Given the rapid evolution of the

education and training systems in both countries, this form consisted of familiarization with and contextualization of national reports and documents.

2. Content matter. The specialized nature of the UK science degree has left many teachers unprepared for the interdisciplinary courses which are gradually coming about. The modular nature of the USA degree has left many teachers with a content knowledge, which, even if broad is often shallower. In both cases, content related courses are needed which are both broad and deep: perhaps an impossible consideration.

On one thing the Group was definitely united: the need for a drastic expansion of well designed professional support systems.

PART VI

STRENGTHENING THE VOICE OF PROFESSIONAL ASSOCIATIONS IN SCIENCE EDUCATION

Papers by:

James J. Gallagher
Peter J. Scott

Discussion

James J. Gallagher
Michigan State University
East Lansing, MI

Strengthening the Voice of Science Education Organizations:

One U.S. Viewpoint

There may be a rather direct lineage connecting medieval guilds, scientific societies, and science education organizations. Sociologists have pointed out the relationship between the first two. (1) Medvitz and Watson implied the relationship between scientific societies and science education organizations. (2) To a greater or lesser degree, all three share the common functions of regulation, communication among peers, and public relations.

The regulatory function of such organizations includes establishing standards of entry into the field of endeavor and monitoring execution of responsibilities by practitioners. The function of communication among peers includes formal communication of relevant information and an open forum for debate and criticism through journals and public meetings. The public relations function includes such actions as promoting the image of the field to the general public, recruiting new members into the profession by providing career information to young people, and political action in the interest of the organization's members involving centers of power and influence

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(such as government and industry). (3)

Regulation

The regulatory function of science education organizations is minimal. Other groups have acquired regulatory authority. The major gate-keepers on entry into science teaching in the U.S. are the Departments of Education in each of the fifty states. In some cases, that authority has been delegated to universities that have teacher education programs, although State Education Departments usually retain the authority to establish standards for these programs. Such standards tend to be quantitative (numbers of credits required in each of several areas) with almost no appraisal of program quality or effectiveness.

A short case history of science teacher certification in Michigan serves to highlight the position of science education organizations regarding regulation of teacher certification. In 1970, the Michigan Department of Education attempted to streamline its certification code and combined three specific certificates for early secondary science into one general science certificate. It was the intent of the universities, as they developed new general science programs, that prospective science teachers who earned the general science certificate would be prepared to teach general science in grades 7-9. However, the Michigan Department of Education chose to interpret this certificate as qualifying students to teach all sciences in grades 7-12 in the same way that a generic certificate in mathematics or English or social studies allows teachers to teach those subjects at all levels in secondary school. The change took place thirteen years ago. It took ten years before university science educators and the Michigan Science Teachers Association (MSTA) became aware of the discrepancy between teacher educators' intentions and the actions of the Michigan Department of Education. During the past three years, MSTA has been working with the Michigan Department of Education and the Michigan Legislature to rectify the situation. MSTA has recommended that no more blanket certificates be given that allow teachers to teach all secondary science subjects and that current blanket certificates be declared void in 1990. That decision would give the holders of these certificates six years to recertify as teachers of biology, chemistry, physics, earth science or junior high science. However, response has been slow because unions do not favor the changes because some teachers could potentially lose their jobs. Administrators and school boards do not favor the change because it would restrict their ability to assign science teachers as needed to teach any secondary science course. Thus, even though this unfortunate situation has existed for several years and even though a rational solution has been offered by MSTA, acceptance has been deferred because of the vested interests of other more influential groups. (4)

This case history underscores the need for science education associations to take a stronger stance regarding issues of entry, qualification, and certification of members of the field. It also underscores the need for more effective political actions, a point about which more will be said later.

Another regulatory area includes monitoring the execution of responsibilities by science teachers. Without authority regarding entry, it is unlikely that science education organizations can have much influence in monitoring the quality of members' performance in executing their responsibilities. Again, unions, school boards, and administrators hold authority in these areas. Moreover, since unions are typically in an adversarial relationship with school boards and administrators, there tends to be little monitoring of the quality of teaching in classrooms in most schools. Science teaching has been characterized by a high degree of teacher autonomy in several research studies. Thus, it appears that a significant void exists in the professional realm of science teachers, which raises questions regarding the possibility of science education organizations filling that void. The task seems mind boggling. Since science education organizations have such limited resources, it would appear that they can have little role in monitoring teaching practices.

It would be more fruitful to recommend: (a) standards for classroom instruction and (b) program standards for elementary schools, secondary schools, and teacher education programs.

Useful program standards have been developed and disseminated. (5,6,7) It would also seem that standards of classroom practice for teachers could also be developed. Both of these could provide teachers with tools for self-evaluation that could result in improved instructional and program quality. Moreover, wide dissemination of such standards might stimulate administrators and school boards to increase efforts at assessing the quality of instruction and program organization in local schools and at helping to bring about improvement.

The bottom line regarding the regulatory function is clear: U.S. science education organizations have little clout! Therefore, public relations and internal communication with members of the science education community become crucial.

Communication Among Science Educators

Formal communication among the members of science education organizations occurs through publications and meetings. Informal networks of communication are also very important, and these tend to be enhanced by organizational membership and by sharing a set of purposes and values. The paragraphs that follow will only deal with the formal communications among science educators that occur through associations. Informal networks tend to be too complex for easy analysis; that fact does not minimize their importance, however. (8)

Formal communication within science education organizations tends to focus heavily on popularizing ideas and approaches in an advocacy role. Critical analysis and debate are not common. There are, of course, exceptions. We occasionally see "letters to the editor" and "comment and criticism" sections in science education journals. We even had "The Great Debate" at ASE between advocates of two views of science teaching. But, in general, science education organizations tend not to be characterized by critical debate. Instead, adherents to differing viewpoints and philosophies tend to advocate their viewpoint and ignore others. This may be more related to the characteristics of science educators than any criticism of science education organizations since the values dominant in an organization cannot be greatly different from those dominant in their constituency.

The consequences of advocacy without criticism and resolution are perceptions of uncertainty and lack of direction such as Yager and I found in our surveys of science educators. When five groups of science educators, including persons from both pre-college and college levels, were asked to list the chief problems facing science education, the most frequent responses were: (1) lack of clear goals and direction for science education and (2) lack of leadership. (9) It appeared as though science teachers and teacher educators had observed advocates of conflicting directions and purposes but had not been able to reconcile these conflicts nor had the science education leadership taken a clear stand. At present, there are no clear answers to crucial questions such as: (a) What constitutes appropriate science goals for schools? (b) What is scientific literacy and how can it be engendered and appraised? (c) What methods of teaching and classroom management are most effective for achieving the specified goals of science teaching?

Granted, simple answers cannot be given to these complex questions; but, consonant with the spirit of science, we should be working to give tentative answers to guide present practice, recognizing that a decade hence our answers may change.

A closely related matter concerns the definition of the knowledge base for science teaching. It differs from that of scientists (10) but it is real, increasing in scope, and gaining more relevance to practice as we better understand (a) the nature of knowledge, (b) the preparation that young people need for a changing world, and (c) how to engender desired knowledge and values in learners.

Science education organizations have at least four important roles to fill here. First, the organizations can help define and disseminate the knowledge base itself. By promoting critical debate and serious scholarship, science education organizations can give direction to the field by helping to clarify what constitutes significant knowledge relevant to science teaching.

The second role is closely related -- translating the findings of research into practice. Two years ago, at the first Bi-national Conference on Science Education, I recommended this as a crucial course of action. (11) Some beginnings have been made. Four issues of What Research Says to the Science Teacher are important steps in the right direction. However, much more systematic and concerted effort is needed, not only on the part of NSTA, but other science education organizations must follow this lead.

With the exception of the series What Research Says to the Science Teacher, there are few mechanisms to help communicate research findings to practitioners in a usable format. Current journals are not doing this very effectively, largely because they rely on submitted articles, few of which deal with this concern. Reviews of research tend not to meet the need because they tend only to summarize findings but not apply them to practice. This brings us to the third role of science education organizations -- to formulate and nurture new vehicles for communicating research findings to practitioners in ways that are useful for improving practice. Science education does not have the equivalent of the Agricultural Extension Service or the Medical Education Division of American Medical Association or the sales representatives for pharmaceutical companies, which help to transmit the results of agricultural and medical research and development to farmers and doctors. Science education desperately needs such vehicles. Science education organizations, utilizing external support from private or governmental foundations, are in a good position to provide them, especially now that the utilitarian value of science education is currently receiving so much attention in the U.S. (12)

In planning mechanisms for communicating the practical applications of research findings to a practitioner, it is important to recognize the receptivity of practitioners to new ideas and the sources they use to acquire new information. Hurd has pointed out that science teachers and professors of science education, as a group, read less than their peers from other fields. (13) My studies of teachers in a single school district showed that, with one exception, the teachers read little, and their acquisitions of new information was unsystematic and slow. (14) Television, especially programs like NOVA and National Geographic Specials, played an important role in science teachers' acquisition of new scientific knowledge. (15) However, no counterpart in pedagogical knowledge existed on television, and teachers did not read or use other sources of acquiring knowledge in that domain. Therefore, the fourth role of science education organizations is to engender attitudes among teachers that will foster continuing professional growth in both instructional content and methodology.

Public Relations Politics

Educators, in general, and science educators specifically, are not attuned to nor particularly skilled in public relations. We are even less skilled in the art of influencing public policy. This may derive from our belief that (a) the public knows that what we stand for is inherently good and (b) "good" will ultimately triumphs! Both these beliefs are, at best, naive.

At the present time, U.S. pre-college science teaching and science teacher education has come under severe criticism by several groups comprised of respected leaders in a wide range of fields. (16) These criticisms focus on the ineffectiveness of school programs to prepare youth in science for work and citizenship in our changing technological society. They also stress the poor quality of university programs for educating science teachers both before and after entry into teaching. These reports have been widely discussed by the media, Congress, and most state legislatures.

Over two years prior to these reports, Project Synthesis was released along with a report by the NSF and the U.S. Department of Education which addressed national needs in science and engineering education. (17, 18) These reports created some interest on the part of the media and the public but nothing on the scale of such reports as A Nation At Risk. (19) There are many reasons that the earlier reports did not create the ferment that more recent ones engendered. Nevertheless, one message is clear: science education organizations need to be more skilled in the art of public information dissemination.

Similarly, public and media concern about deficiencies in school science has waned prior to appropriate action on the part of legislative groups in state capitals and in Washington. Further, much of the money allocated by the NSF for research and development in science education remains unexpended even though several hundred investigators have been waiting for action since last July. As mentioned earlier, Michigan has not taken action to correct an acknowledged error in certification of science teachers. The reasons behind these and other examples of inaction are complex, but the fact that science educators lack the propensity to engage in political persuasion may have contributed to the slow progress.

The public image of science teachers and university science educators has not been enhanced by recent reports of poor quality science programs for school students and their teachers. In fact, it may be at an all time low. Science education organizations have a responsibility to help turn public opinion in our favor. Programs like Search for Excellence in Science Education may help. (20) However, the consequences of these programs need to be examined to determine their effects on science teachers of other subjects, parents, students, administrators, and communities.

Science education organizations may need to give more attention to recruitment of new members into teaching. In many states, the shortage of science teachers is substantial, and science education organizations could aid recruitment through disseminating career information.

Summary

Clear articulation and dissemination of the goals and purposes of science teaching are essential. Before we can win public support, we must speak with a degree of unanimity about what we hope science education will accomplish for young people.

We must also identify the methods of organizing and teaching content (as implied in the goals) that will be most effective in achieving the purposes to which we, as members of a profession, subscribe. Instructional effectiveness will be enhanced through thoughtful deliberation regarding goals, critical analysis of research findings, and sagacious translation of these findings into new programs and approaches for use by classroom teachers.

These activities will help to specify and enrich the knowledge base that science teachers and university science educators must use to carry out their professional responsibilities. Science education organizations play a key role in establishing the spirit of analysis and constructive criticism that will make this effort productive. In addition, science education organizations will need to establish new mechanisms for (a) fostering more productive attitudes and values regarding professional growth and (b) disseminating information and ideas to science teachers and teacher educators. In short, science education organizations and those who run them must give renewed, serious thought to helping all members of the science education community at elementary, secondary, and tertiary levels acquire a more productive base of knowledge and attitudes that will benefit them in the changing times that lie ahead.

When we address these tasks in a disciplined, critical way, we will be able to get our internal "house" in order. At the same time, we must learn to be more effective in communicating with the lay public and improve our skills in the art of politics.

This is not to be critical of past labors or those who directed them. It is simply to recognize that the task is much more difficult than we thought it was!

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THE CONTINUED DEVELOPMENT OF THE VOICE OF THE PROFESSIONAL ASSOCIATION

Introduction

The systematic organization of teachers of science began in 1900, when the Association of Public School Science Masters was founded. It became the Science Masters' Association in 1919. The Association of Science Teachers was formed in 1912 and became the Association of Women Science Teachers in 1922. The Science Masters' Association and the Association of Women Science Teachers merged in 1963 to form The Association for Science Education.

This year, the child of that marriage comes of age at a time when national economic, political, and social changes are greatly affecting the future direction of education in the United Kingdom, and each curriculum component is attempting to respond sympathetically -- none more so than science. So rapid have been the changes in the past two decades that the Association for Science Education has been continually modifying and expanding its work to meet the effects of the increase in non-selective education, local government reorganization, the raising of the school leaving age to sixteen, the introduction of new technologies and, more recently, the moves towards training and

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education for capability.

Against this background of increasing pluralism, the Association has continued to modify its role while catering to a membership that continues to grow. The growth in membership contrasts with a decrease in the overall pupil population. In practice, the number of those pupils taking science is increasing.

In 1973, at a time when most of the Nuffield and the late Schools Council Science Projects had been developed and tested, the Association, at its Education Conference (held annually at the University of Nottingham), devoted considerable time to discussion by the region delegates and officers so that they could become introspective and consider the future role of the Association. Much of what was discussed and suggested at that time has been implemented, but there still remain a number of issues that have not been resolved. Ten years on, in a rapidly changing educational environment, it is fitting that the Association should now address itself to its continued development.

The Present Position

Following the publication in 1981 of its Policy Statement, "Education through Science," the Association became a co-sponsor, together with the DES and the late School Council, of the

Secondary Science Curriculum Review. Within the three-year period ending in 1986, this major project, under the leadership of Dr. Richard West, will review current practice, develop new strategies and materials, modify approaches to the teaching of science in the eleven through sixteen age range, and through these processes change attitudes both inside and outside the science teaching profession. The emphasis will be placed upon developing a variety of models for a balanced science curriculum for all pupils, using 20% of the available curriculum time. Balance between content and process will be achieved, and knowledge-based courses will be redressed towards a more skills-based approach. The sophisticated and complex curriculum development model places the responsibility for evaluation, innovation, and change firmly upon those with the working knowledge -- that is, the teachers. Many of these teachers are members of the Association, and they are working in numerous groups and cells on an inter-school and intra-school or college basis. In most cases, the Local Education Authority (LEA) Science Adviser acts as facilitator to the groups, all of whom are linked to the Central Team by a Regional Project Leader who is a permanent member of the Project Team. Through its four members on the Steering Committee, and in other ways, the Association is fully supporting and actively assisting in the work of the Review.

It is to be hoped that many of the current shifts in educational thought -- resulting in environmental, social, political, economic and technological changes -- will be incorporated within the guidance given to science teachers during and at the conclusion of the Review. Among the changes in the educational climate are:

(a) a recognition that science is within and part of the overall curriculum and not a separate, isolated component. Thus, communication studies (literacy, language, numeracy and oracy) are as much the province of the teacher of science and the sciences as they are of any other teacher;

(b) moves towards criterion-referenced assessment (graded tests, profiles, continuous assessment) from the norm-referenced examinations;

(c) the enhanced professionalism of teachers as evidenced by their working together within a school or in a local group, producing ideas and material to meet their own particular needs.

The Association, too, must represent the changing needs of its members, and it will continue to address itself to these requirements, making all material developed available for use by the Project.

Through the Education Coordinating and Education Research Committees, working groups of members are advising the general membership by publishing articles in the Association's journals and by producing materials in numerous areas of development. These include:

(a) the changing nature of assessment;

(b) the requirements of the Special Education Act (1981), with particular reference to Science for Handicapped Pupils, Science for "Gifted" Pupils, Science in the Multicultural Society, and Science for the Least Able Pupil;

(c) increasing emphasis upon the management, organization and administration of science departments;

(d) the realization that different industries present a vast source of untapped information relating to the application of science, the study of which can make science lessons more relevant;

(e) the effects of unemployment and the shift of financial resources from the Department of Education and Science to the Department of Employment, which has resulted in a shift from education to training, an unproclaimed raising of the "education leaving age," and numerous initiatives from the Manpower Services Commission, with emphasis upon different skills training;

(f) a ripple effect from post-sixteen education, which is affecting younger pupils, as more pre-vocational and vocational courses are introduced from the age of fourteen to the age of nineteen;

(g) recognition that Science, Society, Technology and the Environment are inextricably interwoven, and their effects cannot be considered independently;

(h) the need for younger children to be exposed to good science teaching early in their primary education if they are to develop the knowledge, skills and attitudes which will enable them to understand science and preserve their enthusiasm and motivation as they become older;

(i) the initial, induction, and in-service needs of the science teacher.

The Roles of the Association

The Association has a number of roles in which it engages. Amongst these are the advisory, collaborative, consultative, developmental, initiatory, information-giving and support roles. Some exist as member requirements while others relate to external bodies. All are interdependent. Since 1980 there has been a marked shift towards the role of adviser, collaborator and consultant by and with individuals and organizations outside the Association, with whom the ASE enjoys an increasingly effective cooperation with mutual advantages. Among these organizations are:

(a) Learned Bodies, such as the Royal Society, the Royal Institution, the Royal Society of Chemistry, the Institute of Physics, the Institute of Biology, the Institute of Geology and the Royal Meteorological Society, and other organizations such as the Standing Conference on School Science and Technology;

(b) Subject associations, through COSTA (Council of Subject Teaching Associations) in this country and through ICASE (International Council of Associations of Science Education) with regard to overseas science organizations;

(c) Government: various departments (Education and Science, Trade and Industry, and Employment), the Parliamentary and Scientific Committee, Select Committees of the House of Commons and the House of Lords;

(d) H. M. Inspectorate, as advisers and observers on numerous working parties and consultative groups;

(e) Industry, and in particular British Gas, Unilever, British Telecom, Shell UK, British Petroleum and numerous small and medium-sized companies who are corporate members of the Association;

(f) Local Education Authorities, through Advisers, and the

Society of Education Officers;

(g) Government bodies, such as the Equal Opportunities Commission, the Race Relations Board and the Health and Safety Executive.

Representatives of these and other groups regularly visit headquarters and receive members, while increasingly those representing the bodies are also members of the Association. However, a balance of roles must be achieved if the members are to receive the information and support needed to initiate, develop and consolidate science courses to meet their requirements.

As the economic realization dawns that education is an investment and therefore accountable to those who allocate money, then the Association, which is financially independent, is being asked to monitor and act as guardian of standards in such matters as safety in school laboratories, apparatus design, and the training of teachers and technicians.

The role of information disseminator is a rapidly expanding one as more textbooks, software and resources, in-house and external publications are sold and dispatched from headquarters. Moreover, information on innovative approaches, syllabus planning, organization, (to include activity and grouping), appropriate resources, organization and administration of the school and college laboratory, managing departments and links with colleges and university departments of education is increasingly being sought by members.

The Future

The work of the Association in recent years has resulted in greater respect and attention from those outside the membership. This attention has further resulted in increased credibility and a concomitant expansion of proposals to the Association to undertake work and offer advice on an ever-diversifying range of projects. The officers and members must pay attention to this relatively new effect. Success does increase success, but incorrectly handled success can quickly dissipate.

First and foremost, the Association must address itself to the welfare of its membership -- those members who pay an annual subscription for advice and information. Clearly, advice and information can only be given if the Association engages in external work where ideas are shared and created. The balance is important.

In this context, the Association is at a watershed, and the future must witness a more critical approach by the membership in making decisions relating to involvement in a widening range of initiatives. The responsibilities of elected officers become more exacting, and decisions must not be lightly taken but should only be reached after wider consultation and critical discussion within the membership.

In the immediate future, the Association must complete those projects in which it is currently involved. Unfortunately, the situation is dynamic, and these projects lead to a widening involvement. It is difficult to foresee the outcomes, but trends can be discerned, and generally these fall into four areas in which there is a measure of overlap. These are curriculum innovation and implementation, the professional development of science teachers, legislation, and the effects of new technologies upon the teaching of science.

(a) Curriculum Innovation and Implementation

(i) As co-sponsor, the major commitment and involvement will be with the Secondary Science Curriculum Review. From this work will stem considerable knowledge about the balance between process, content and skills of science, which can be disseminated to all science teachers. The concern will be for balanced science education for the majority without neglecting the needs of minority groups. Inevitably, the Review will consider the question of the assessment of the pupils and, through this work and the work of the Association's Examination and Assessment Subcommittee, members will have access to a wide range of techniques, a number of which will concern the pupil as an individual and will not be related solely to science teaching.

(ii) The Review's terms of reference limit its work to curriculum development for pupils within the age range eleven through sixteen. Outside this range, the Association will continue to monitor and advise upon initiatives, to develop material and assist members in primary/junior/middle school science, as well as being involved in the diverse and rapidly changing area of youth and adult education. This will involve a greater liaison with bodies such as the Manpower Services Commission and the Further Education Unit and therefore means links with government departments other than the DES. Moreover, the vast and relatively untapped area of expertise and knowledge within industry and commerce will continue to be explored in order to enrich the scientific and technological components of the curriculum. Inevitably, the Association will become involved in developing science and technology components of the curricula for the education and training of pupils in the fourteen through sixteen age range in schools and colleges, components which must form part of the new technical and vocational initiatives. Moreover, in the long term it will be involved in continuing education for adults and will encompass a wider involvement in technological, environmental and historical aspects of education.

(iii) To assist in these developments, there will be expansion of publications and software to meet the changing curricula and assessment procedures. These will include in-house publications for the benefit of members and other bodies concerned with education in science and technology.

(b) The Professional Development of Teachers of Science

(i) The innovations of the Validation Board are being implemented and will be widened to include the continued professional development of teachers of science in their initial, induction, and in-service education. In-service education will include the retraining of some teachers to meet the needs of a changing educational scene, and much will be linked to the SSCR. This will involve a greater dialogue with government and government-sponsored organizations such as the DES, the Secondary Examinations Council, the School Curriculum Development Committee, the Manpower Services Commission and the Further Education Unit. Additionally, closer contacts will follow with LEAs through their Advisory and Inspectorial Divisions and with Her Majesty's Inspectors of Schools. The professional needs of members will continue to be served by regular meetings, such as the Annual Meeting, the Education Conference and meetings at region and section levels. The emphasis will be placed upon assisting and encouraging members to meet in small, like-minded groups at the power base of the Association -- the regions and sections and in cells within departments in and across schools, thereby assisting LEAs and teachers to plan school-based and school-focused in-service courses.

(c) Legislation

The increasing area of legislation as it affects education will be the third area. Acts such as the Health and Safety at Work Act (1974), the Sex Discrimination Act (1975), the Race Relations Act (1976) and the Special Education Act (1981) contain numerous legislative clauses that affect the teaching of science and technology in schools. Groups will study these acts and, where relevant, will advise members of the implications through the journals of the Association.

(d) The Effects of New Technologies on the Teaching of Science

This is by far the most difficult area to assess and includes such fields as biotechnology. The microelectronics revolution is ensuring that new apparatus for use by pupils and teachers is reaching educational establishments. At the present time, technologies such as fibre optics and lasers are on the verge of breaking into education. Following in their wake will be future generation technologies based on those now in existence and also as yet undiscovered technologies. These will have to be monitored with a view to advising the membership on their best use in education and in distance learning. In this context, the Association must consider a greater involvement with the media to increase public awareness and understanding while enhancing the public image of science.

5. Concerns for the Future Development of the Association

The growth in the membership of the Association has been substantial in the past decade; the activities in which it engages have increased, and its continued success and respectability are apparent to a wider audience. With this growth, as is the case with any developing organization whether it be professional, industrial, or commercial, there has been an increase in discussion and introspection concerning the future direction of the Association and the extent of its commitment. The rate of change has become so rapid that decision-making and timing have become extremely important. The Association has to be managed professionally, and it is to the credit of the permanent staff at ASE headquarters (under the skillful leadership of the general secretary and the elected members, and in particular the past chairman of the Association) that the ASE continues to flourish. The relation between the general secretary and the chairman can be likened to that of the director of education of an authority and the elected chairman. The latter ensures that policies determined by the membership are implemented. The former actually implements them.

However, the present 17,000 members represent diverse opinions on science education, and obtaining consensus policy is not easy. On the other hand, from the polarized extremes of opinion is generated the dynamism that continually promotes healthy discussion on all relevant matters. With continued growth in membership -- it is estimated that there are about 42,000 teachers of science in schools and colleges in Great Britain -- (so an untapped pool exists), the scope of interest widens even more with further diversification of operation for the Association. Yet the recruitment of new members is of paramount importance if the present healthy financial position of the Association is to be maintained.

Any association must represent its members' wishes, and these are changing. The communication between the school-based member and the decisions of his/her elected representative must be effective; otherwise, there is concern that the association is establishment-based and less concerned for the individual members. If the membership of the association is made more attractive, then teachers and lecturers will not readily question why they should join and what is provided that could not be found elsewhere. It is difficult to know what the school-based teacher requires for his/her reasonably-priced annual subscription of 16 pounds, but high on the list is the desire to keep abreast of current developments in both knowledge and teaching strategies and to find security through contact with other professionals.

The prime aim of an association is to be effective in carrying out its stated aims, and these should be continually reviewed so as to ensure that they reflect the needs, interests and aspirations of all teachers in a changing society. Effectively carrying out these aims, which must be precise and clearly spelled out, leads to a more professional approach. At present, the aims of the Association restrict the representation of an increasing number of members who wish the Association to make statements on such matters as conditions of service, improvement in working conditions, levels of finance and ancillary assistance as well as levels of competence in the profession, including assessment, appraisal and accountability of members. From the rules, the Association is subject-based and not a professional group or a union of like-minded teachers.

With the recent introduction of academic validation and professional recognition, the Association has taken a step towards becoming a professional organization. With increased recognition of the professional competence of teachers or the corollary, a lack of recognition by the Association of those who are unqualified or lacking in competence, the move towards becoming a professional association is accelerated. Members expect to be protected from teaching in unfamiliar subject areas without appropriate and adequate in-service retraining. The peculiarly British notion that when a teacher is qualified, he/she can teach all ages and all abilities in a subject, is manifestly absurd. Clearly, the aims of the Association are in need of revision to accommodate this recent shift.

As the Association becomes increasingly involved in science education from primary through higher education and adult continuing education, the indiscriminate acceptance of additional work must cease, and each proposal received must be critically and thoroughly inspected. However, quick and accurate decisions must be made if suitable initiatives are to take place. The elected members must make the decisions on behalf of the ordinary members, but meetings are relatively few, which militates against democracy. However, the desire to be seen to be democratic can lead to procrastination and the consequent weakening of the Association position. In this respect, the position of the Chairman becomes crucial since he or she must quickly obtain the opinion of the membership and make the necessary decisions in light of that opinion.

With the continued development of the work of the Association, the present structure of its membership will have to be scrutinized. The elected members, who are usually full-time teachers or lecturers, become overworked as do the permanent staff. As a result, matters may not be fully discussed, and decisions could be taken too lightly. Decision making at the Executive and Council indicates that these bodies are too large, and there is also evidence that too many working parties exist, some of them repeating work that has already been done. Happily, the move towards flexible and negotiable job descriptions for all officers, and terms of reference for future working parties, is taking place. However, the strength of the Association is undoubtedly in the work carried out in the regions and sciences by a considerable number of members giving freely of themselves to the activities.

The Trust Deed and Rules of the Association need annual revision in light of current developments. The charitable status of the ASE needs clarifying since at present it militates against continued development. As of now, the Association's work is a function only of members' subscriptions, but increasingly industry and commerce will be willing to assist financially, but not without benefit to themselves. Should an association like the ASE follow this line?

The Annual Meeting has become so successful that it is now becoming difficult to accommodate all of the members who wish to attend. Increasing acrimony is to be found among the rank and file members who, either because of financial constraints or meeting dates clashing with term times, cannot attend. To a certain extent, this is true of the Education Conference but not for the same reasons. Here, competition for the limited places is so fierce in some regions that members feel rejected and frustrated when they are not able to contribute while other regions are more "laissez-faire" when selecting representatives.

Both these events will, through necessity, come under closer scrutiny over the next few years.

Conclusion

The voice of the Association will continue to be heard over the next few years, but with a change of emphasis. The expanding roles of the Association make communication most important. The ordinary member must be kept fully informed of the current work of the Association, and great skill is needed in identifying those members who could make major contributions to that work and who should thus hold senior positions. Such members must be given adequate time to carry out their responsibilities.

The views presented are personal and should not necessarily be taken as the views of the Association for Science Education.

Discussion: Strengthening the Voice of the Professional Association in Science Education

Plenary
Gary Appel, Rapporteur

1. The importance of organizations effectively communicating with members was identified as critical to promoting successful practices.

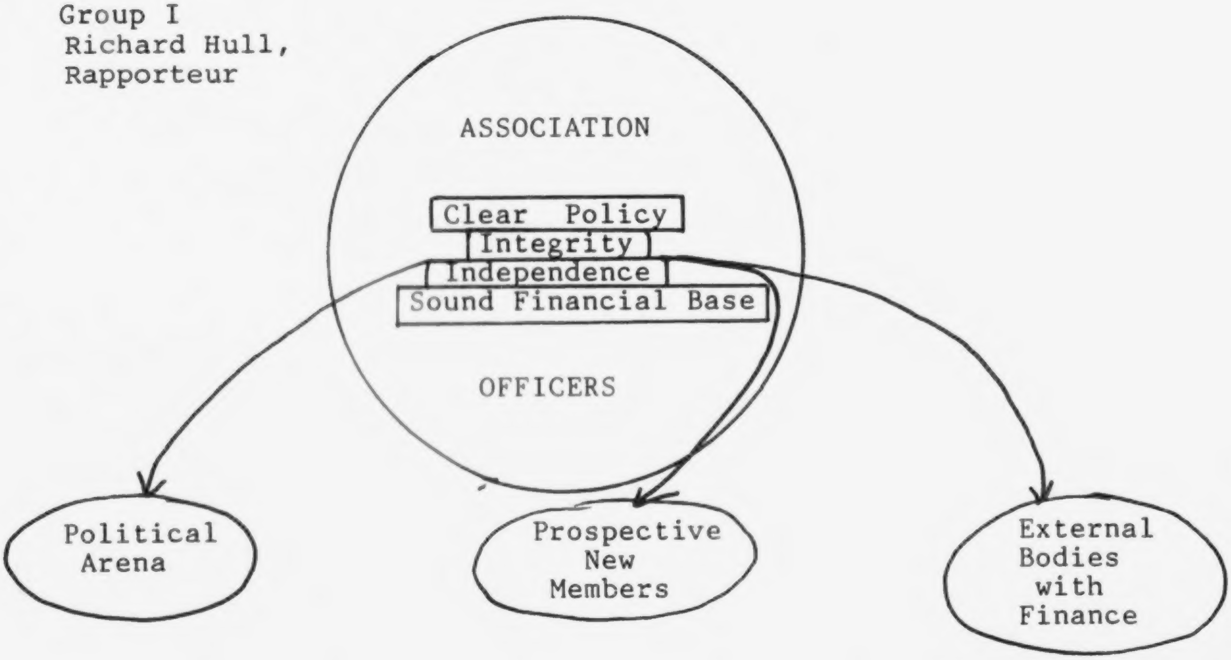
2. The issue of professional associations controlling entry into the field of education was suggested and rejected.

3. The issue of having "Royal Societies" was suggested and rejected.

In the discussion following the P.M. Professional Organization rapporteur reports, this issue was raised:

It was pointed out that the NSTA identifies exemplary programs through its Search for Excellence process.

Group I
Richard Hull,
Rapporteur


ASSOCIATION
Clear Policy
Integrity
Independence
Sound Financial Base
OFFICERS
Political Arena
Prospective New Members
External Bodies with Finance

The diagram above summarizes the discussion. The key aspects of an association are its independence and integrity. Independence needs to be assured by keeping an association or a sound financial base, using its subscriptions and any soundly based business activity. Integrity starts from a clearly stated policy. The officers of the association have then got a clearly defined position from which to conduct the association's business.

It was felt that an association with a strong base of this kind was in a position:

a. To conduct negotiations in the political arena. The group believed that this was an important aspect of an association's task and that it was likely to build confidence in its membership to assure that the association was looking forward and clarifying how future policies might affect science education. A corollary to this was that communication needed to go right down to the local level within the association, to ensure proper agreement and support.

b. To negotiate with external bodies for funding, as long as any activities were in the general interest of the membership and in the general direction of defined association policy.

c. To seek new members with a clear statement of what the association offered. It is important, therefore, to make sure that these services are good in themselves and a good value for the money.

d. To produce from its own ranks the number of really active members necessary to ensure the association's good health in the future.

The group recognized the vital importance of communication within an association but realized how difficult it is in practical situations, particularly when very rapid responses are required. It was felt that the existence of a clearly stated policy and the generation of opportunities for members to express their views on issues (most importantly in the formulation and revision of the policy itself), together provided a good form for communication. However, this was an issue that needed to be kept clearly in focus.

Group II
Alan Winfield, Rapporteur

Strengthening the Voice of the Professional Associations

What should Science Education Organizations attempt, and how should they go about it?

NSTA members felt that their organization ought to be discussing the purpose of science education and taking the lead

Group III
Glen Aikenhead, Rapporteur

The group was unanimous in believing that the prime function of a professional organization is the welfare of its membership. However, unity of purpose for the membership caused considerable discussion. Polar views on science teachers were identified. ASE and NSTA were perceived as walking a different line in between diverse positions (e.g., between progressive science educators and conservative science teachers).

The differences in functions between ASE and NSTA were explained in part by noting that while U.K. science teachers will or will not belong to the ASE, their U.S. colleagues have many more choices of professional organizations, many of which are independent of each other (e.g., state, city, subject organizations). The ASE is much more involved than NSTA in inservice work
through local meetings.

After discussion, there was consensus on the position that ASE and NSTA as democratic organizations ought to lead and inform opinion rather than merely reflect it, in spite of the fact that members would rigorously disagree. It seemed evident that ASE members had more opportunity to voice their concerns to the ASE executive via structural channels than do NSTA members.

Recommendation 1: NSTA may wish to review this function.

Recommendation 2: NSTA publications should be readily available for purchase from ASE, and vice versa, taking advantage of bulk shipping across the Atlantic, currency translation by one's own organization and copyright fee in the foreign country.

The following controversial issues were raised for critical debate:

(a) the proposal to issue diplomas and certificates by the ASE

(b) the role of ASE and NSTA public relations function

(c) the role of ASE and NSTA in consulting in a school-based manner

(d) coordinate and evaluate science education products such as textbooks and software

The spirited debate led to the conclusions that:

(1) promoting science teachers ought to be a function of ASE and NSTA especially in objectively communicating with stake holders in science programs (e.g., the business and industry who hire school graduates)

(2) ASE and NSTA ought not to participate in a local consultative role

(3) Descriptive reviews of education products benefit members. Associations should issue explicit stamps of approval. The Search for Excellence project in the U.S. was recognized as a form of "stamp of approval" by NSTA on certain district and school programs

Group IV

John K. Gilbert, Rapporteur

Strengthening the Voice of Professional Associations in Science Education

The Group addressed three aspects of the theme: Reputation, Communication and Public Relations.

It was felt that the notion of producive Reputations was limited both by political reality and by the Trust Deeds of the associations. However, it was thought possible to:

1. Make Recommendations

For example, it was suggested that the Associations produce recommendations on the minimum laboratory size and equipment that was compatible with a policy of activity-based science education. The need for minimum availability was stressed so as not to inhibit more generous provision. It was also recognized that this had implications for qualified teacher supply at a time when 'science for all' was being adopted as policy within both countries.

2. Exert Influence

The involvement of classroom teachers in the selection of trainees, the design of courses, and certification procedures, as is shortly to come about in the UK, was pointed to as a clear example of the way that influence could be directly brought to bear.

3. Provide an Example

The establishment of the Presidential Award for Excellence in Science and Math. Teaching is a powerful way to set an example. It was proposed, somewhat tongue-in-cheek, that the Duke of Edinburgh (who is Patron of the ASE) should be persuaded to extend his Award Scheme, which recognizes activities by young people to the science teaching profession. In a more serious vein, it was suggested that a parallel to ASE's 'Five ta Sychrey' competition, which sends five young people to Australia bi-annually, could be developed in relation to the USA. It was thought, in relation to such pupils and teachers, that team-based awards were the most desirable.

In terms of communication, it was felt that documents generated by awardees in the above schemes could be made widely available.

Much attention was paid to public relations. It was felt that:

1. teachers should be educated in the art of self-presentation. An ability to respond positively to criticism, and to emphasize the great societal contribution of science education, was needed.

2. the actual conditions of teacher services should be widely publicized in order to counteract the wide-spread perception that school teachers have an easy life.

3. the Association should attempt to recruit national-level decision-makers who influence and advise legislators.

Overall, the Group felt that the Associations need to be more active in the political world.

PART VII

SUMMARY OF THE CONFERENCE

by

P. J. Black

P. J. Black
Centre for Science and Mathematics Education
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SUMMARY OF THE CONFERENCE

A Brief Encounter

How to sum up a conference? There are many choices. I could be naive: Cindy Hrebar gave us the summary "Blow in, Blow up, Blow out," but I'm not sure whether that describes the intellectual or the gastronomical transactions. Or I could try to be sophisticated -- Malcolm Frazer's suggestion -- "Post-Operative Illuminative Cognition" -- will do for starting at this level.

A different sort of choice lies between the superficial -- I could recount what happened -- and the profound -- I could try to reveal the deep inner meanings of our transactions. The former is safe but of little value. The latter can be of inestimable value if one hones in on a valid insight -- but the chances of missing this target and merely talking nonsense are rather high. So I steer a middle course to optimize the product of risk with value.

Any intensive and friendly meeting, such as this has certainly been, produces its own family atmosphere, its characteristic jokes and unusual characters. Our three chairmen

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showed considerable talent at presidential badinage, but this entertaining skill only showed that they had been managing their serious roles in the N.S.T.A. with a deft and light touch. Peter Scott was likewise firmly in charge with considerable skills, those of a British headmaster and of an A.S.E. chairman. His early morning running set us an example, and also brought us problems. I'm still wondering what the unit, the Snood, with which M.I.T. students have marked out their bridge, could be. Connoisseurs of educational mnemonic jargon will not, of course, have any difficulty with such a challenge: for example, Serendipidous Numinous Operational Oriented Dialectic describes our work quite well.

So we were managed -- even constrained. Thirty-seven professional educators, meeting together for the first time, can't be made to work intensively for three days at a single task without a clear framework and firm control. Al Medvitz and his three Boston colleagues looked after this very well, but inevitably, we were rather like pupils in a school. The timetable was imposed on us; we were moved around territory which was owned by others and not by ourselves; our "outings" were arranged for us; we even had our own tea-mugs with our names on the bottom -- which for Britons in Boston is rather too suggestive.

So we were in a close, controlled, intensive atmosphere. The fact that such control was necessary and productive will not --

perhaps should not -- prevent me from pursuing the school analogy. Like any school, we had our curriculum, the topics of the programme. But we were also bound to have our hidden curriculum, and we had our school ethos -- the feelings, values and motivations that drove us and tuned the tone and mood. This way of looking at our work also gives me a way to sum it up. I want to talk about the moods and feelings, then about the overt curriculum and the hidden curriculum, and finally about relating all three aspects.

Moods and Feelings: Inside and Outside

In any discourse, the mood and the tone of what is said is often as important as the actual words themselves. In this respect, our first day revealed paradoxes. While Sid Sitkoff's account of educators getting on with their job within their system came across with his enthusiasm, Mike Williams' concern with the outside world moving in -- to interfere, control, perhaps oppress -- was heavy with foreboding. The quantitative criteria of business efficiency are seductive to many who want to improve our world -- if we can measure both output values and input costs, surely we can proceed to optimize the ratio. There was no joy at this prospect among this group of scientists -- our epistemology is sharp enough to spot that ratios are only meaningful when the numbers are measurable on scales that satisfy certain strict conditions. So we feared the numbers of the philistines.

The discussions of technology also had their paradox. Both Audrey Champagne and Mary Linnington reported a mixture of enthusiasm for the new windows that computing technology could open, and deep fear about its effects. Again, loss of control faced us, as pressures to buy, and the invasion of the classroom by stereotyped products unworthy of the talent and potentials of our pupils, loom as threats -- old ones (to be sure) but now reenergized by new technologies. Added to these fears of the outside were a different kind of problem -- that of being disoriented by the changes that new developments in educational technology could bring. In this tension, between the excitement with the new prospects and the fears of invasion and disorientation, our fears seemed more powerful than our excitement.

The subsequent two days were quite different. With the start given by Peter Durrant and Alejandro Gallard, we struggled with the problems of diversity, coming to clear, positive, and shared commitments. We should tackle these problems head on, by teaching in mixed classes rather than avoiding or deferring resolution by teaching separate classes. The problems are clearly enormous, but our responsibility to pupils and to society dictates that we attack the problems rather than evade them.

Similarly with research and teaching, both Malcolm Frazer and Jim Robinson were anything but complacent, but our community of teachers and researchers accepted their message that there is a problem and worked together at ways of tackling it.

The same was true of the other interface discussed on the third day. Cindy Hrebar and Ballinda Myers saw real problems and spelled out tried strategies to ensure that an advisory and innovative service really would help teachers. Peter Scott and Jim Gallagher struck the same positive note, but here once again we faced the world outside, and the mood became more uncertain.

The small size of our group, our close relationships, and the balance between teachers, advisers and researchers meant that this meeting provided an unusual forum for discussing problems internal to our system. Whenever we were doing this, the mood was positive, collaborative, and optimistic. But it must say something about our situation that when we looked outside our circle at problems in relating to other parts of society, the picture was quite different. Academics defending their disciplines would dictate what we taught, an unappreciative public and business community would try to tell us how to teach it, and politicians threatened to control (through powers of purse and preferment) our means to teach and our ability to tackle our problems in our own way.

Perhaps our world of education has been too cozy and protected, and we have become unfit to relate properly to society as a whole. Is this true, and if so, then must we start to listen to what others have to say about our aims and methods? Both Jim Rutherford and Dr. Hoy, speaking to us from outside, threw light on this question. Up to a point, their message was the same: we are forming the next generation, and so the future of the world is our special burden. We should be cheered at the importance of our aims. But the messages were not so clear about the direction of these aims.

Dr. Hoy spoke of the growing technologies, such as robotics, control and communication, micro-electronics; the need for high quality manpower was clearly foreseen. Jim Rutherford sounded different -- perhaps because he was trying to look further ahead to the year (2040?) when today's new pupils will be in their prime. With the probability of fundamental changes in both the power and the nature of our technology, he could not easily define long-term aims: we have to equip our pupils to survive and hopefully prosper in a man-made world quite different from our own.

Thus today's politicians and industrialists may be no better placed to predict what future citizens will need from their education than we are. So while the outside should not frighten us and while we should listen to its voices carefully, it will not speak to us with a single voice, and we shall not be able to do more than share a little of that responsibility for our future.

Overt and Hidden Curricula

There is no need here to summarize the ideas set out in the papers and discussions. The overt curriculum is delineated fully in the rest of this report. There were, however, various levels of hidden curricula that have become apparent during the meeting. I want to talk about these by describing some of the issues under two general headings.

The first heading is inputs, and it subsumes a set of issues that recurred frequently throughout our discussions. I think this happened because they were essential inputs to such discussions. That is to say, we could proceed when we knew where we stood with them. We stopped short when we lacked knowledge or experience to deal with them.

The first issue concerned the aims of science education. It should be designed to meet the needs of pupils, but which pupils, and in what aspects of their future lives? All the following possibilities merit attention:

-- as scientists, a few need to become practitioners or helpers, and we must inspire some students to choose these roles;

-- as employees, many will need the knowledge and most could benefit from the skills that we can promote;

-- as citizens, all will need to appreciate how and why their world is changing, and be able to decide between the many alternatives that science and technology will increasingly provide;

-- as people, all will need as much help as we can give them to understand themselves and their relationships to others and the outside world.

There was clear agreement that we must meet all of these types of need, that we had given little priority to citizens and to people in the past and that we must serve them better in the future.

A second issue concerned the definition of our curriculum. While the academic disciplines do define the underlying conceptual bases, they do not on their own provide a curriculum that makes sense to most children. Most students experience everyday issues as they are, and not as laboratory issues that different experts set up and analyze. Indeed, solutions of real problems usually require the resources of various disciplines but also require the combination of these resources as needs dictate that we cut across subject boundaries. In order to attract or be really useful, our curriculum must be reformulated in terms of a dialogue between the concepts and skills that established disciplines can provide and the issues and problems that define the needs of the world and that are the foci of concern for our pupils. This dialogue may only be achieved by fundamentally restructuring our teaching so that it is an alternation between the analytic acquiring of resources from disciplines and the synthetic use of these to tackle real problems.

Thirdly, we need more and better insights into methods. Whole class teaching and individualized learning have both been subject to much research and analysis. However, collaborative learning in small groups has a special part to play, both for science classes of mixed abilities where pupils help one another to learn and for the pursuit of problem-oriented project work. We need more work on this method and better guidance on the optimum articulation of all three approaches in overall teaching plans.

Fourthly, we need to think harder about how to relate to our customers -- pupils, parents, employers and the general public. Development of broader and more meaningful tools for assessment and evaluation can be a powerful help here because these can provide the information on which the communications, with pupils themselves and with others, can be based.

The second heading is systems, and it encompasses a collection of issues concerning the way in which our strategies for change might be planned in the future. In our discussions three main guidelines emerged.

First, we need to pursue a long term and consistent strategy for developing science education. The humorous description that has likened many of our past projects to a bandwagon pulled by hobby-horses is too near the truth to be merely funny. We ourselves constructed these chariots and rode off on them, pretending that this time we had the new trick to solve all problems. The net result of such efforts was Jim Robinson's shattering comment that when he returned to the science classroom after a twenty year absence, he found it had hardly changed. Should not a mature reflection suggest that the main difficulties, and the means to their resolution, are sufficiently well understood that we can now apply ourselves more patiently, modestly and consistently?

Second, we need to improve the links within our system between researchers and teachers, between teachers and teacher-trainers, between supporters and those they try to support, and between teachers and curriculum developers. The links must be reciprocal, and opportunities for individuals to cross the interfaces in both directions by changing roles must be provided. When any one of these bodies starts suspecting (or even attacking) the work of another, we should pause and take care, for internal dissensions weaken us all.

Third, we cannot pursue our aim to serve all citizens, and our strategy to do this through work on the issues and the problems of our world, without spreading well outside the boundaries of science and into other curriculum areas. Yet we must not be imperialists claiming that other areas, such as technology or health education or environmental education are our exclusive property. They are not -- each is a meeting place where several traditions and types of knowledge have a role. The reform of the science curriculum can only prosper if it is part of a broader policy for the curriculum as a whole.

A Proud Profession?

If from the curriculum of this meeting we have discerned a strategy for future development of science education, our variations in mood have shown that the confidence and independence that we need to carry it through may be seriously lacking. We have oscillated from the competence and enthusiasm of keen professionals to the fears and uncertainties of a down-trodden minority. However, the policies we want to follow and the importance of our task to society show that we need to stiffen our resolve to be -- and to be seen to be -- a determined and mature professional group. How are we to repair our confidence and restore our standing with the rest of society?

Here I can only pick up some clues from our meeting. We must proclaim the importance of our task -- it is too easily undervalued. We must show the highest concern for the quality of our work, particularly in our commitment, at whatever cost, to high standards of initial and in-service training. We must pursue unity and mutual support. However, all these could be realized by a profession that was mainly concerned with protecting its own interests, claiming more power and reward than was its due, and limiting the legitimate interests and rights of society in its work.

So we must do more. One need is for an ethic and a code: I don't know how to begin to meet this one except with the idea that we should as far as we can serve the needs of each child by considering him or her as a unique individual. Another need is that we have to admit the limits of our powers. In schools, teachers often know too well that they are bearing the brunt of the destructive social and family conditions that some children suffer, and that they can only alleviate the harm done. This is borne out more broadly by the oft repeated research result, that parental and home background is the most important single determinant of a child's educational performance. We are limited, and our success will always depend on the wider achievements and failings of society. A third need is always to qualify our demands for resources. Of course, we often have a right and a duty to demand more resources for our work, but nobody will take us seriously if we are not also vigilant in trying to make better use of the resources that we have.

That begins to sketch a programme for our two associations -- and it is one on which, in part, they have already been working. What is striking about this summary is that it has very little to say about the bi-national composition of the meeting. Some factors could be found, e.g. differences between the work of the two associations in representing their profession to politicians, or between the experiences of teachers with external examinations. Such matters are not trivial, but they were of small importance compared with the common experience and perspective that we were able to develop.

If that was so striking, do we need to cross the Atlantic to meet at all? My own view is that we gain in a unique way from the passage. We are sufficiently different that we can force one another to take a fresh look at ourselves and see our problems from fresh angles, yet we are sufficiently similar that we can quickly and fruitfully exchange existing ideas about policy and solutions, and generate new ones from our encounter.

That could mean that our collaboration stops before we come to execution -- since turning ideas into practice requires adaptation to the particular structures and details of different national systems. The truth of this does not detract from the value of our meetings, but it needs to be recognized if we are to appreciate the sorts of outcome that our meetings can and cannot achieve.

However, I want to close with a suggestion that this should not be the whole story. Both of our countries have a tradition over the past twenty-five years of trying to help the development of science education in the Third World. I say "trying" advisedly because our success has not been conspicuous; many of our attempts have ended in exported artefacts gathering dust in cupboards. In both our countries, many now try to make a more thoughtful and constructive contribution to science education in other cultures. Is this not a task in which we could share ideas and experience?

I'm sure we could develop our fruitful friendship by continuing to work on one another's problems, but a friendship is often the better, even in selfish terms, for turning to cooperative work on the problems of others.

PART VIII

THE COMMENTS OF TWO PARTICIPANTS TO THE REPORT BACK SESSION OF THE NSTA ANNUAL MEETING

Comments by:

Val Payne
Cindy Hrebar

Val Payne

Personal Impressions: What I'm Taking Back With me to the Classroom in U.K.

First topic hard business image of cost effectiveness. We started with a vision of beautiful ways. Of course, we must justify what we do with resources that are diverted to us from other areas, but one of our presidents suggests wouldn't it be beautiful to allow pupils to succeed and enjoy science, to let them love their learning, let them realize that they can take responsibility for their own learning. It was suggested that cost effectiveness is to be found in increasing the effectiveness of teachers, well supported teachers with the new technologies individually fitting into their repertoire of skills. This was the central theme for me personally -- increasing my effectiveness, our effectiveness with our pupils and students. How did the conference help in this?

I felt very much part of the "family of science educators" -- classroom, teachers, researchers, advisors, administrators -- working together -- coming to a closer dialogue with each other and hopefully with our other non-science colleagues in school in our joint venture of educating the young. In his opening address, James Rutherford put forward the idea of starting the curriculum from scratch to get around cultural arts and science divisions. I believe the themes that we explored over the three days will help close the gap between the 'haves and have nots' in

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science education and also overcome the 'them and us' of arts and science.

In working appropriately with the new technologies in school, we were urged to plan first and buy later. Sound advice. We all want to appear up-to-date and popular, and it is tempting to jump on the newest bandwagon. There are so many bandwagons that seem to have the answer to life if only they would slow down enough for us to jump on. As a head of a department in school responsible for several teachers and many pupils, a great deal of my time is spent trying to keep up-to-date with the latest apparatus, the latest syllabi, the latest books, the latest curriculum developments in teachers' courses; hoping to inform myself before jumping in a particular direction. So what are we doing with the computer? Our pupils can be in another world with the computer, enjoying new laws of motion and exciting as 'Star Wars,' but they can get lost in a false world, thinking that truth resides in the computer. Students must be able to ask the right questions and use data sensibly. GIGO (garbage in, garbage out)! Again, we are giving them opportunities for learning. Our task is to manage that learning process -- getting the computer out of its special room and into the classrooms and taking computers across the curriculum.

In some ways we have an advantage -- our sciences are related to technology; the computer is technology -- but we must not just grab at the new toy. In our session on access to science education, one question caught me by surprise. "Can science address a diversity of learners?" It had not occured to me that science education, in one appropriate form or another, is not available for all. It stressed again the need to think across the curriculum in enhancing the student's self-esteem. I am aware of the shortfall of girls in science education and of women in scientific and technological employment and have my own intuitive reasons for that. But in working together in this conference and discussing research into the different ways that pupils have for processing information and gaining control over the environment, my own mind is less closed, less localized.

In the past I have shied away from research findings, or at least said to myself, "I'll wait until someone has incorporated them or translated them into some curriculum programme that I might use." In a sense, I excluded myself from those in the ivory tower who had produced them. But this week, sitting side by side with them, I've been able to say, "I'm interested in what you are saying, but I'm having difficulty in understanding you." We have been able to find a common language for communication. My fear was that in being in the classroom with a particular class at a particular time, any exploring I did would lack objectivity and credibility, but this week in our international dialogue, I've gained the confidence to feel that through my own classroom based research I can develop a sensitive and self-critical perspective, and it is not damned by its subjectivity, and in doing so I can increase my effectiveness and that of others.

A minute ago I was telling you how hard pressed I was. Now I'm telling you I'm taking up research in the classroom as well. Well, I have my feet firmly on the ground, but I have my dreams. If they were not realizable in the past, I would feel very frustrated, and I would be ineffective. I need support, and our final sessions brought home to me, too, the strength that lies in our professional science associations. Perhaps their greatest strength lies in continuing to help us to cope with the rapid changes and make sense of the information explosion that threatens to overwhelm mere mortals. In the conference we have been contrasting and comparing our experiences but always coming back to our common task. I am slightly ashamed to say that I learned a great deal about my own Association for Science Education in our Boston discussions.

But it seems to me that this is the whole point of such a meeting -- that we learn about others and ourselves in the meeting of minds.

I've tried to put myself inside the skins of those people I have met -- the researcher and teacher educator, whom in the past I have tended to dismiss with the flip remark, "I wonder when they were last in the classroom." They've helped me move away from the chalk-face and take a broader view.

I've tried to put myself inside the skins of my American counterparts, experiencing their difficult classroom conditions, their materials and constraints.

I've tried to put myself inside the skins of those who run our professional associations.

I hope I've not ended up as a schizophrenic. I feel I have more skills now with which to listen to the many people who educate, both those within science education and without, on this side of the Atlantic and the other. In this lecture this morning, Paul deHost Hurd reminded us that so many (some 80%) are excluded from any science education. He urged us to go back to our schools and districts and work out what we want our pupils to know in science, what we want them to do, what we want them to value when they leave us. Then, having done that, he suggested we do the following: 'beautiful ways' -- he suggested that we write down clearly and present to parents why we say we want to exclude 80% of their children from this place. I haven't got the courage to do that, but I feel after this conference and this convention that together we may find the resources to include all our students in science education.

Cindy Hrebar

Reflections on the International Symposium of the NSTA/ASE

Balance....Appropriate...Future....Linkages

These four words capture my reflections of the dialogue that occurred among the science educators from the United States and the United Kingdom who participated in the International Symposium of the National Science Teachers Association and the Association of Science Education. Once semantics and organizational structure were understood, it became evident that our visions, our concerns and our resolutions were indeed similar.

Balance

Both countries have provided well for the 10 to 20% of the student population that eventually enter science-related professions. There was a consensus that it is time to broaden our perspectives and provide "science for all."

This vision carried curriculum implications. While meeting the needs of all students, it was agreed that the dignity of the discipline must not be sacrificed or compromised. We did not advocate soft science but real science that would address personal and social concerns and would include problem solving. Science education would not become better or worse. Rather, it

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would be different.

Appropriate

In striving towards the goal of "science for all," we recognized that teaching strategies must not be overlooked. Strategies need to be viewed from the viewpoint of the teacher as well as that of the learner.

Teachers will need to select optimum teaching styles to maximize learning for students. To accomplish this teachers will have to develop a repertoire of techniques so that appropriate strategies can be chosen to achieve the desired outcomes.

Future

Currently both associations have assumed a posture of responding and reacting rather than being positive and proactive. We felt an urgency to project the image of a proud profession.

How can we be positive? One immediate way would be to celebrate and publicize our numerous successes. How do we become proactive? No one knows better than we science educators what constitutes good science. Therefore, it was suggested that we enter into open and honest discussions, compile our best thoughts in policy statements and then widely circulate the resulting document.

Linkages

Good practices exist in the classroom where curriculum becomes alive and meaningful for students. The sad fact is that little is shared among teachers. We advocated the establishment of networks within which resources, practices and ideas could be exchanged among fellow teachers.

We recognized the normal tendency to focus solely on our own areas of expertise. We felt the need to transcend these narrow boundaries, to look at all pieces of the puzzle we call science education and to work together in developing a synergistic whole.

A Final Statement

Words are meaningless unless translated into action. The challenge is to deal with the issues that emerge from "balance," "appropriateness," "the future" and "linkages." If so done, we will emerge from the crisis of confidence and the crisis of concern into what Fletcher Watson, Harvard physicist, has called the "crisis of possibility."

APPENDIX I

THE BRITISH AND AMERICAN EDUCATIONAL SYSTEMS

by

John Head

APPENDIX I

Dr. John Head
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The British and American Educational Systems

This brief note is not intended to provide a detailed analysis and comparison but just to describe the background and clarify terminology.

1. The British System

Some differences exist between the four countries in the United Kingdom, and this description refers more closely to the system found in England and Wales.

The central government exercises considerable control through the Department of Education and Science (DES), which is headed by a cabinet minister. The department decides on the main policy issues and, through its inspectors (HMIs), monitors the system nationally. The department is responsible for the 'recognition' of qualified teachers. The same salary scale, pension rights and conditions of service prevail throughout the country.

The Local Education Authorities (LEAs) act as agents of the central government and are responsible for the day-to-day running of the schools. The LEAs have to act within the policy guidelines produced by the DES, which can be a source of conflict. The LEAs are responsible for a larger area than most

American School Boards (there are a total of 105 LEAs in England and Wales responsible for 9 million pupils). The LEAs also place staff into schools (Advisors) to monitor the work going on there.

Education is compulsory from the age of five to sixteen. The most common pattern is to attend a primary school from the ages of 5-11 and a secondary school after 11, but other patterns exist, including the provision of middle schools for pupils aged about 9-13. Until recently, the secondary schools in many areas were divided into grammar schools for the most able and secondary modern schools for the less able, but nowadays all-ability, comprehensive schools are almost universal. Traditionally, the bulk of the school population leaves school at 16 with only the potential college students staying on until 18, but recently an increasing proportion of the 16-18 population has stayed in full-time education, probably as a consequence of the lack of employment opportunities.

The first year in a secondary school (i.e., the 11-12 year olds) are known as the first form, the next year the second form, and so forth. Most pupils leave school at the end of the fifth form, aged 16. The two year period for 16-18 year old students is anomalous, as the two years are just called 'the sixth form.'

The public examination system is crucially important, as entry to higher education and many jobs will depend on achievement in these examinations. The first hurdle comes at the age of 16 at the end of the fifth form (tenth grade). The students either take the General Certificate of Education Ordinary Level (GCE O-level) or the Certificate of Secondary Education (CSE).

Originally, the GCE was aimed at the most able section of the population and the CSE for the average student. It is intended that these two examination systems should be amalgamated. An able pupil might offer seven to eight subjects at this level.

In the sixth form, the student would probably specialize in studying three subjects to be taken at the age of 18 in the GCE Advanced Level examination.

The system is such that all secondary schools must participate in the public examinations, but they are given some choice between different syllabi, which are on offer. The individual teacher has to bear in mind the need of the students to pass these examinations but is given considerable freedom on a day-to-day basis about how and what to teach.

2. The American System

The system is much less homogenous with the constitution denying the Federal Government direct power in education although active, interventionist governments in the past have wielded considerable influence by indirect means.

The individual States undertake many of the functions that are centrally controlled in the U.K., e.g., the accreditation of teachers, recognition of schools, conditions of service, etc. Very considerable power lies at the level of the local school boards and with their superintendents. The larger school boards would correspond to the British LEA in size, but the majority are much smaller than any administrative unit in the U.K.. In that sense the local community has more direct control of their educational system. School boards may influence the school curriculum by approving certain textbooks and objecting to others. The finance of education comes from local sources so that in the U.S. there exists greater variety in the provision of facilities, such as laboratories and gymnasiums, than in the U.K. The best American schools are lavishly equipped, but others are not. Teachers are paid on a local scale, which varies enormously according to the wealth of the area.

Compulsory education usually extends from the age of six to sixteen, but the majority of children attend a kindergarten year and also stay on at school until the age of 18. The most common pattern is to attend elementary school until the age of about 12 and then move on to high school. The latter are often divided into junior and senior high schools, so that a variety of post-kindergarten patterns exist, e.g., 6 : 6 years, 6 : 3 : 3, 4 : 4 : 4, 6 : 2 : 4, etc. In all cases, the first year at elementary school, composed of the six year olds, is called the first grade, the next year the second grade, and so forth. The tenth grade, to take an example, corresponds to the British fifth form and the twelfth grade to the British upper sixth form.

Each American student studies about four main subjects each year, and each year's course is self-contained with the student gaining a credit for that year's work. Usually the timetable has a daily cycle, whereas most British schools follow a weekly cycle. During one year's study of a science, the student will probably spend about one hour a day of every day in the year working in that subject.

The lack of a national examination system means that the selection for entry into higher education is largely determined by how one graduates from high school, i.e., the grades obtained in each year of the school. Entry into higher education is much easier in the U.S. than in the U.K., and a higher proportion of the population continues their education after the age of 18. The first year of American degree courses is fairly broadly based, which allows the student to try a variety of subjects, or compensate for studies missed at the high school level, before committing himself to the specialization of the major subject. Most first degree courses take four years, rather than three as in the U.K.

3. Science Curricula

In Britain the student would study some science in the first two or three years in the secondary school and then have to opt for one, two or three sciences for the next few years to be studied for the GCE O-level or the CSE examination. Again a choice has to be made on entry to the sixth form as to which three subjects to study for the next two years. Some students will retain three sciences right through their school career; others may drop all but one science by the age of 14. In the latter event, they would find it extremely difficult to change course later on and take up a scientific career.

In America some general science would be studied prior to the tenth grade, and then the students could choose to include science among their elective subjects. A student could take biology in the tenth grade, chemistry in the eleventh and physics in the twelfth and end up with a measure of specialization approaching his British counterpart.

Comparisons are difficult, but I would judge, on the basis of having taught in schools in both countries, that the American High School student graduates with a level of science in his elective subject roughly equivalent to the knowledge possessed by a British student at the end of the first year in the sixth form.

For the able student who knows that he wants to study, the British system allows earlier specialization and a more rapid advance within the chosen areas. The American system probably offers a better deal for the less able student and for one who wishes to keep the options open so that crucial career choices can be made at a later time.

APPENDIX II

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